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Human Movement Responses to the  
Rorschach Test and Embodied Simulation:  
An Interdisciplinary Investigation.

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## Preliminary Notes

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## Abstract

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Since the discovery of the mirror neuron system increasing attention has been paid to the role of embodied simulation and MNS in the understanding the feelings and intentions of others. In fact, the idea that empathy may be deeply grounded in the experience of a lived body and that understanding the mental states of others employ the MNS has a huge innovative potential especially in clinical and dynamic psychology. Originating in this cultural and historical framework, the present research aims to investigate whether a Rorschach response process traditionally interpreted as being associated with understanding the feelings and intentions of the self and the other is also associated with MNS activity, as one may expect given the theoretical overlapping. The Rorschach response process under investigation is that underlying the production of human movement (M) responses. The attribution of human movement to the ambiguous inkblot stimuli of the Rorschach test, indeed, has been considered an index of a person's capacity to establish empathic contact with another human being since almost 100 years. Five studies were undertaken. A first, pilot, study exploited a phenomenon known as 'neurological priming' and investigated the association between M responses and MNS activity indirectly. Three EEG studies and an fMRI study followed, aiming to examine more directly the brain activity during exposure to different Rorschach stimuli. Taken together, the results of these five studies suggest that, as predicted, the production of M responses on the Rorschach test is associated with MNS activity. The implications for the test's validity are discussed.

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## Introduction

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Since the discovery of the mirror neuron system increasing attention has been paid to the role of embodied simulation and MNS in the understanding the feelings and intentions of others. Several psychological theories have been revised and reformulated in the light of the embodied simulation hypothesis, and a growing body of research in many areas of psychology has been focusing on the activity of the MNS. Constructs like empathy, mentalization, theory of mind, and intersubjectivity have often been associated with (and sometimes reconsidered in view of) these recent progresses in neuroscience, and the “shared manifold hypothesis” has become a key concept in multiple domains of psychological research, including developmental, social, and clinical psychology. In particular, the idea that empathy may be deeply grounded in the experience of a lived body and that understanding the mental states of others employ the MNS has a huge innovative potential in clinical and dynamic psychology, and paves the way for infinite research hypotheses and theory reformulations. Indeed, it can be easily said that most of the tradition in clinical and dynamic psychology has primarily focused exactly on understanding the feelings and intentions of the self and the other.

Originating in this cultural and historical framework, the present investigation aims to reconsider some traditional conceptualizations related to the Rorschach test in the light of these recent acquisitions in neuroscience. More in detail, the goal of the present work is to investigate whether a response process traditionally interpreted as being associated with understanding the feelings and intentions of the self and the other is also associated with MNS activity, as one may

expect given the theoretical overlapping. Should this association be confirmed, a neurophysiological foundation for such interpretation would be offered, and our knowledge on the relation among understanding the feelings and intentions of self and others, response elaboration processes to the Rorschach test, and brain activity would be broadened.

The theoretical framework and the rationale for the study are discussed in detail in chapter 1: the first part of the chapter is a literature review on the Rorschach response under investigation (i.e., the human movement response); then there is a brief review of the concepts of theory of mind, reflective function, mentalization, psychological mindedness, and empathy; following is an introduction and brief review of the concepts of MNS and embodied simulation; ultimately a description of the rationale for the study, along with formal hypotheses, is presented. The main hypothesis is that a certain kind of response to the Rorschach test, i.e., the human movement (M) response, is associated with MNS activation.

In chapter 2 a pilot study indirectly examining this hypothesis is presented. In a few words, a small sample of students were administered some Rorschach cards immediately after having showed them some short videos expected to activate the MNS at different levels. It was hypothesized that if M responses and MNS activity were associated, then the participants would produce more M responses when exposed to the videos that activate more intensely the MNS, because of a sort of 'neurological priming'.

Chapter 3, 4, and 5 present two investigations conducted with the electroencephalography (EEG) technique. In the first EEG study (chapter 3) a few selected Rorschach stimuli were administered, along with some drawings, to a small sample of students, while recording their EEG data. The main hypothesis was that the MNS would be more

active during exposure to the stimuli that elicit feeling of movement (i.e., Rorschach cards with high M response frequency in the normative database) as compared to the stimuli that do not elicit feeling of movement (i.e., Rorschach cards with low M frequency in the normative database). In the second EEG study (chapters 4 and 5) the entire set of Rorschach stimuli was administered to a larger sample of students, and the association between MNS activity and several kinds of Rorschach responses was examined more directly. The main hypothesis was that M responses would be associated with MNS activity.

In chapter 6 a further investigation of the relationship between M responses to the Rorschach test and MNS activity is presented. Adopting a similar methodological approach to that used for the second EEG study, a sample of nonclinical adults were administered the Rorschach test during functional magnetic resonance imaging (fMRI).

Chapter 7 is a conclusive consideration on what all these findings suggest, in terms of Rorschach literature and personality assessment.

# CHAPTER 1

## Literature Review

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### ***The Human Movement Response to the Rorschach Test<sup>1</sup>***

The Rorschach test (Rorschach, 1921) is an assessment instrument employed to identify nonobvious overt and covert behaviors and respondent characteristics. It is primarily used in diagnosing underlying thought disorders and differentiating psychotic from non-psychotic thinking in cases where the patient is reluctant to openly admit to psychotic thinking. However, it is also useful in detecting personality characteristics of patients and in evaluating their emotional functioning. Recent research addressing the utility of Rorschach test, indeed, suggests that “the test is particularly useful in (a) individualizing case conceptualizations and interventions and (b) predicting and evaluating outcomes”. (Viglione, 1999, p. 251).

The test consists of ten ambiguous static images formed from inkblots, an ideal tool to bring out subjects’ perceptual uniqueness. Indeed, freedom of choice is given by the ambiguity of the stimuli, while a constraint is given by the distinct instruction to identify a suitable representation for the stimuli (the request is: “What might this be?”).

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<sup>1</sup> Most of this section is made up of materials which appear in Porcelli, P., Giromini, L., Parolin, L., Pineda, J. A., & Viglione, D. J. (in preparation). The mirror neuron system and the determinant of movement in the Rorschach: single or multiple constructs?

This instruction enables patients to focus on matching internally generated representations with an externally existent visual stimulus that serves as a distinct goal.

Each response to the Rorschach cards is scored according to the distinct perceptual classes of features that are selected by the subject as relevant for identifying a specific representation for the stimulus, namely the form (contour) of the blot (e.g., “it looks like a butterfly because of the shape”), the color (e.g., “the shape and the color makes it look like a red butterfly”), and shading (e.g., “a storm cloud because of the different shades of gray”). A fourth characteristic or determinant of the response is the movement, i.e., the subject identifies an object not only because of form, color, and/or shading of the stimulus but also because he or she “experiences” the sensation that the object (a human being, an animal, or an inanimate object) is moving. These movement responses are the type of determinant that is not contained in the actual Rorschach stimulus, but added to the stimulus field, presumably as a product of ideational and imaginal activity of the subject.

Among the three kinds of movement responses that occur in the Rorschach test, involving either humans (M), animals (FM) or inanimate objects (m), Rorschach scored for only one type of movement, that involving human beings or human-like behaviors. He discounted animal movement (and even more that involving inanimate objects) as having the same meaning as human movement which, in his firm belief, is based on the mechanism of identification: individuals identify themselves with the other human figure seen in the blot because they are able to reproduce the feeling of movement within themselves, as if they move themselves (Malmgren, 2000; Rorschach,

1921), a process that is referred to as “kinesthesia”<sup>2</sup>. In other words, the movement seen in the perceived object has to be reproducible within the sense of the body of the individual. This is possible when the object is a human being making a movement typical of the human species (e.g., “a man sitting at a table”) and not possible when the object is an animal that is making a movement common to the animal species (e.g., “a bird flying in the air”). The process of kinesthetic identification is even less possible when the response involves an inanimate object in movement (e.g., “smoke rising up”).

Historically, only Beck (1944) and partly Rapaport, Gill, and Schafer (1946) defended Rorschach’s position while all the other following systems, including the Comprehensive System (Exner, 2003), have argued that the three types of movement responses represent relatively different psychological operations, thus including separate scoring criteria along with critical distinctions in interpretations for human, animal, and inanimate movements.

However, despite these scoring differences, since the publication of Hermann Rorschach’s monograph (1921), M responses to the test are almost unanimously considered as one of the best sources of information about personality dynamics. For example, Mayman (1977) argued that M responses are “the richest, most revealing, consistently more interesting responses which occur on the Rorschach test” (p.230) and Piotrowski (1977) that they “provide, more than any other single test component, specific and significant information about the individual’s role in the interhuman relationships that matter to him” (p.189). This additional interpretive value attributed to M responses by

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<sup>2</sup> Although the word ‘kinesthesia’ in the Rorschach literature is often adopted with this H. Rorschach’s denotation, it should be pointed out that a more appropriate wording within the cognitive science and neuroscience field could be something like “kinesthetic identification”, “mimicking” or “simulating”.



outstanding authors of the century-long history of the Rorschach test might be one of the reasons why this determinant category has been retained in all the Rorschach systems despite the major changes that have occurred from one system to another (see for example, Exner, 1969; Meyer, Viglione, Mihura, Erard, Erdberg, 2011).

Roughly speaking, the rationale for the interpretation of M responses relies on two main considerations. First, when the subject reproduces within himself the feeling of movement seen in the blot, to some extent he or she also identifies with the moving human figure seen in the blot. Therefore, M responses should reveal information about the respondent's ability to identify with other human beings. Second, to be able to match internally generated representations of human movements with externally existent ambiguous stimuli, it is necessary that the representation of such human movements is present and available in the mind of the subject. Thus, to be able to produce M responses, the subject has to be able to think about human beings and human movements. Accordingly, M responses should also contain information about how the respondent thinks about human beings.

Mostly because of these two main reasons, for almost 100 years – although from different perspectives and with some distinctions – all the theorists have conceived M responses as indices of higher cognitive functioning, ability to think about and understand the feelings and intentions of the self and the other, and capacity to establish empathic contact with other human beings.

For Klopfer (Klopfer & Kelley, 1942), M serves as the basic indicator of a well functioning personality bridging the gap between inner resources of drive and fantasy and the outward orientation of reality testing and object relations or interpersonal schema, manifesting creative capacities, the acceptance of one's own self and inner

promptings, and richness of the inner life. According to Beck (1944), Ms represent those strong emotions that the subject is able to contain internally thereby converting them to adaptive and creative processes. Piotrowski (1957) expressed a more articulated view of M responses, suggesting that they always imply interest in people, awareness of the self, concern with the future, and mostly the subject's "role-in-life" which was defined as definite tendencies that are basic characteristics of the personality. According to him, Ms stand for the most individual and integrated strivings which dominate the individual's life and indicate traits stabilizing the relation between the individual and his environment. They are potential not actual actions, initial stages of actions at a very low level of intensity. From the perspective of the psychodynamic model of Ego Psychology, Rapaport, Gill, and Schafer (1946) claimed that M responses indicate the ability to delay the individual's emotional response, the readiness to make anticipations, the flexibility of perceptual and associative processes in general.

Borrowing from all these traditions, Exner (2003) focused on the cognitive aspects of the M response and proposed that it involves the elements of reasoning, imagination, and higher forms of conceptualization; a form of delay from yielding to more spontaneous responses to the environment during which time an active and deliberate form of directing one's inner life occurs. He gave less emphasis to the social cognition component.

A wide body of empirical research has shown that M responses are consistently associated with ideational and social processes including field independence (Witkin, Dyk, Faterson, Goodenough, & Karp, 1962), effective interpersonal relations and behaviors (Exner, 2003), ego strength and introversion (Greenwald, 1991; Hix, Ebner, Stanford, Pantle, Kerr, & Patton, 1994), ability to cognitively process emotions (Porcelli & Meyer, 2002; Porcelli & Mihura, 2010; Rhue & Lynn, 1987),

creativity (Ferracuti, Cannoni, Burla, & Lazzari, 1999), dream recall (Orlinski, 1966), and intelligence (Gallucci, 1989; Wood, Krishnamurthy, & Archer, 2003). A predominance of active M responses<sup>3</sup> has been found among women employed as strippers in contrast to a relative predominance of passive M responses among women employed as models (Young & Wagner, 1993). M has also been associated with sensory deprivation (Bendick & Klopfer, 1964); electromyography-based muscle potentials (Steele & Kahn, 1969); ability to discriminate florid and withdrawn schizophrenics from healthy subjects (Di Nuovo, Laicardi, & Tobino, 1988), and symptom improvement after psychotherapy (Exner & Andronikof-Sanglade, 1992; Weiner & Exner, 1991).

Synthesizing, the available literature leads to the conclusion that M responses are an index of higher cognitive functioning and reveal information on the respondent's understanding and thinking about human beings and human relationships. Because of the theoretical overlapping between this latter aspect and theory of mind, reflective function, mentalization, psychological mindedness, empathy, and embodied simulation, a brief review on these constructs follows.

## ***Mentalization and Theory of Mind:***

### ***Cognitivist Perspective***

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<sup>3</sup> In the CS, active movements are coded when energetic, robust, vigorous, lively or animated activities are described; passive movements are coded when inert, quiescent, submissive, compliant, or stationary activities are described (Exner, 2003; Viglione, 2002).

Broadly stated, the term Theory Of Mind (ToM) is referred to as the capacity to attribute mental states to one's self and others and to understand that others have knowledge, beliefs, intentions, and desires, that are different from one's own. Although from different perspectives, the interest towards the ToM is shared by philosophers, cognitive developmentalists, and primatologists. The main shared purpose is understanding the ability to predict and explain the actions of self and others.

From a philosophical point of view, some roots of ToM conceptualization can be found in Lewis (1966), which stated that our access to other people's minds is mediated by an implicit theory of the functioning of the human mind. A couple of decades later Fodor (1987) suggested that this ability (i.e., the capacity to access the minds of other people and make sense of their actions) is innate and develops through a process of maturation, rather than through education. Dennet (1987), in the same year, introduced the notion of "intentional stance", to refer to the fact that we predict and understand other people's behavior by reference to their beliefs and desires. A few years later, other authors, such as R. M. Gordon (1992), have proposed that we understand and predict others' behavior by trying to imagine, or simulate, how the things look from their perspective.

In the field of developmental psychology, the origins of the interest towards the ability of ToM can be traced back to Baldwin (1906), which discussed about children's understanding that others have a psychological, and not just a physical, existence. With the rise of behaviorism (Watson, 1930) this interest almost disappeared for a few decades. Then, in the 1960s and 1970s, a lot of researchers focused on topics like perspective taking, capacity to deduce other people's thoughts, feelings, and intentions, and person perception (Ensink & Mayes, 2010). Of course, among all the researchers that worked on the

ToM, one of the most important authors is Piaget, that made an enormous contribution to our knowledge on the development of ToM in children (Bretherton, 1991).

The term ToM, nonetheless, was actually coined by two primatologists: Premack and Woodruff (1978): In their seminal article, they claimed that chimpanzees may be capable of inferring mental states of their con-specifics. From an evolutionary point of view, indeed, ToM probably emerged as an adaptive response to increasingly complex primate social interaction (Brüne & Brüne-Cohrs, 2005).

Three main competing theoretical accounts of the development and nature of ToM have been offered. They are referred to as theory-theory account, simulation theory, and theory of nativism.

According to the theory-theory account, the growth of the child's ToM results from a continuous reorganization of his or her existing theory in order to account for new evidence in the environment. According to Astington and Gopnik (1991), this position is corroborated by several research findings. For example, success on false belief tasks<sup>4</sup> coincides with the understanding of the distinction between reality and appearance, and with the recognition of false belief in one's self. Also, young children are initially resistant to evidence, and require multiple occurrences of counterfactual evidence before transforming their beliefs. Furthermore, when children's spontaneous gestures are treated as if they are intentional by parents, children – as a consequence – begin to consider themselves as intentional beings and to communicate intentionally (Fonagy & Target, 1997).

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<sup>4</sup> The false-belief tasks are a 'gold standard test' of comprehending other persons' minds. They consist of grasping that others can hold false beliefs that are different from one's own (correct) knowledge.

According to the simulation theory, humans understand other human beings through an identification process, i.e., by simulating other people's experience, actions and reactions through a process of imaginative identification (Harris, Johnson, Hutton, Andrews & Cooke, 1989). From this perspective, ToM is not a continuous adjustment of explicit or implicit theories of mind, and it is not acquired by applying concepts and theories. Support for this position comes from the discovery of the mirror neuron system (MNS), a neural observation/execution matching system.

According to the theory of nativism, ToM emerges because of innate mechanisms in the brain. In other words, according to this position the emergence of ToM capacities relies on the maturation of an innate neurological substrate, and neurological deficits are the source of ToM deficits in psychopathologies like autism or Asperger's syndrome. Leslie (1986), for example, proposed that already at 3 or 4 months emerges the comprehension of the distinction between agents and nonagents. Similarly, Baron-Cohen and Swettenham (1996) stated that an innate mindreading system, or social brain, is specific for the attribution of mental states to agents. Support for the theory of nativism comes from the studies on autistic spectrum disorders. Indeed, it is now widely acknowledged that autistic children and adults with Asperger's syndrome suffer difficulties in appreciating the mental states of other individuals (e.g., Baron-Cohen, 1988; Baron-Cohen, Jolliffe, Mortimore & Robertson, 1997; Baron-Cohen, Wheelwright, Hill, Raste & Plumb, 2001; Buitelaar, van der Wees, Swaab-Barneveld & van der Gaag, 1999). Such deficits in mental state comprehension have been shown to be selective, i.e., other cognitive capacities may well be conserved in people with autism (Baron-Cohen, 1991; Baron-Cohen, Leslie & Frith, 1986).

Regardless of the theoretical position, it is now quite well documented that some ToM capacities emerge earlier than would be expected based on Piaget's theories (for a review, see Brüne & Brüne-Cohrs, 2005). In fact, at around 6 months of age, human infants are able to distinguish between the motion of inanimate and animate objects. At about 12 months they develop the ability of joint attention, i.e., the cognitive capacity to form a triadic representation involving the infant's own perception, the perception of an agent, and an object. At 14–18 months they begin to understand the relation between a person's emotions and goals (Saxe, Carey & Kanwisher, 2004). Between 18 and 24 months they begin to engage in 'pretend play' (Leslie, 1987) and to learn to recognize themselves in a mirror. At around 3–4 years of age they dramatically increase their chances to succeed on false belief tasks. At the age of 5 to 6 years, children are able to understand that someone can hold beliefs about other people's beliefs (Perner & Wimmer, 1985; Wimmer & Perner, 1983). At six and beyond, children tend to begin to understand what others are thinking (Wellman & Lagattuta, 2000), to talk about their own thoughts (Wellman, 1990), and to think about themselves in mental state and trait terms, rather than in terms of physical attributes, capacities, and context (Harter, 1999; Wellman, 1990).

To sum up, the study of ToM abilities in children has been of central importance for several psychologists for many decades. Indeed, how children come to understand and think about the feelings and intentions of themselves and others, and how this affects their future relationships is a key developmental question, especially for psychoanalysts. However, despite the rich literature regarding ToM abilities in infancy and early childhood, only a few empirical data about ToM abilities after the preschool period is available. In fact, the lack of reliable measures and procedures for measuring ToM abilities in this

age constitutes a major limitation for research in this field (Ensink & Mayes, 2010).

For this reason, and because of the relevance of the topic, the interest towards understanding the feelings and intentions of self and others in late childhood, adolescence, and adulthood often shifts from the domain of ToM towards the constructs of reflective function, mentalization, and psychological mindedness.

### ***Mentalization and Reflective Function:***

#### ***Psychodynamic Perspective***

Aiming to analyze adult attachment narratives from a ToM perspective, Fonagy and his co-workers (Fonagy, 1997; Fonagy, Steele, Moran, Steele & Higgitt, 1991; Fonagy, Steele & Steele, 1991; Fonagy & Target, 1997) observed that there are noteworthy differences in the extent to which different people think about their attachment relationships. Some individuals are much less inclined than others to think about these relationships in terms of underlying mental states and affect. This remark led the authors to introduce the construct of reflective function (RF), later defined as “the capacity to envision and think about mental states, in oneself and in others, in the service of building realistic models of why they behave, think, and feel as they do” (Bouchard, Lecours, Tremblay, Target, Fonagy & Schachter, 2008, p.48). Given that similar human skills, such as the ability to understand the mental states of oneself and others, are usually referred to as mentalization, Fonagy, Steele, Steele, Leigh, Kennedy, Mattoon and



Target (1995) operationalized RF as a measure of the quality of mentalization in the context of attachment relationships.

According to Fonagy and Target, “mentalization or reflective function is the developmental acquisition that permits children to respond not only to another person’s behaviour but to their *conception* of others’ attitudes, intentions, or plans’ (Fonagy & Target, 2000, p. 69). Thus, mentalization or RF is a developmental achievement whereby children learn to mentalize the thoughts, feelings, intentions, and desires of self and others. Put simply, it is the result of the establishment of representations of psychological states in the mind of the human infant, and consists of the ability to understand the mental states of oneself and others.

Before achieving this capacity, the child moves from what has been referred to as the ‘psychic equivalence mode’ to what has been referred to as the ‘pretend mode’. The first (i.e., the ‘psychic equivalence mode’) refers to a level of mental functioning where there is no clear distinction between psychic/subjective reality and external/objective reality. Fantasy and reality, in this level, are not well discerned and, consequently, the possibility that others have beliefs and thoughts that may differ from one’s own is not fully taken into account. The second (i.e., the ‘pretend mode’) refers to a level of mental functioning where initial appreciation of the difference between fantasy and reality begins to emerge. In this level the child is able to play and pretend, understanding that what happens in a game of make-believe may be different from what happens in real life. As stated by Fonagy, Gergely, Jurist, and Target (2002): “in the world of play it becomes possible partially to free representations from their referents and allow these freed representations to be modified, creating a more flexible mode of thought that encourages the emergence of latent mental structures” (p. 261). This second level, therefore, allows the

child to begin to understand that mental states are not the same thing as reality, but just a perspective on reality. Such an acquisition will later allow for a deeper comprehension of the mental states of the self and the other, i.e., for the achievement of mentalization abilities.

According to Fonagy and his co-workers (Fonagy, 1997; Fonagy, Steele, Moran et al., 1991; Fonagy, Steele & Steele, 1991; Fonagy & Target, 1997), this achievement depends on the quality of the early relationships, especially with caregivers. Indeed, it is generally acquired by those children whose caregivers are “sufficiently benign and reflective” (Fonagy and Target, 1996, p. 218). This thesis is supported by numerous empirical data. For example, Meins, Fernyhough, Russell and Clark-Carter (1998) showed that mothers of securely attached children have a great propensity to treat their children as mental agents and suggested that this propensity influences the later development of their children’s mentalization. Similarly, Meins, Fernyhough, Fradley and Tuckey (2001) demonstrated that maternal-mindedness (i.e., the maternal tendency to interpret their infant behaviors in mental states terms) predicts attachment security and ToM more than maternal sensitivity does.

Empirical data have recently been reported also for the Fonagy’s RF scale – i.e., Fonagy’s RF measure designed to be used in conjunction with the Adult Attachment Interview (All; George, Kaplan, & Main, 1985). Initial research, indeed, has demonstrated that RF mediates the relationship between parental attachment security and infant attachment security in the Strange Situation (Ainsworth, Blehar, Waters & Wall, 1978): As compared to insecurely attached parents with low RF, insecurely attached parents with high RF were more likely to have securely attached babies (Fonagy, Steele, Steele et al., 1995). Similarly, Grienenberger, Kelly, and Slade (2005) have observed that the relation between atypical maternal behavior and attachment

security in their babies is mediated by mothers' scores of RF. Further support for the validity of the RF scale comes from Fonagy, Leigh, Steele, Steele, Kennedy et al. (1996)'s findings, which suggest that high scores of RF may reduce the possibility to be diagnosed with borderline personality disorder (BPD) among psychiatric patients with a history of abuse. Empirical data have also supported the importance of RF for self-knowledge and insight in therapy (Sugarman, 2006).

This scale has recently received increasing attention in clinical psychology for several reasons. One of the most important reasons is probably that deficits in RF seem to be a core feature of disorders of self and affect regulation, such as the BPD. In fact, patients affected by similar disorders have limited and rigid ideas about their own and others' states of mind, and this may expose them to emotional storms and impulsive actions. Accordingly, mentalization-based therapies have recently been proposed for patients with BPD (Bateman & Fonagy, 2004) and disruptive behaviors in children and adolescents (Bleiberg, Fonagy, & Target, 1997). These therapeutic approaches, instead of focusing on specific symptoms, aim at enhancing mentalization abilities. Thus, they address, constantly and directly, the processes of understanding and communication. The resulting enrichment of the mentalization abilities is probably one of the most important factors toward the improvement of the therapeutic alliance and the effectiveness of several psychosocial treatments. For example, understanding the thoughts and feelings of self and others is likely to be a necessary condition for both cognitive therapy and family therapy. Similarly, RF is likely to play a central role in psychodynamic therapy, in that it influences the understanding of the defensive processes and the reluctance to change (Ensink & Mayes, 2010).

Deficits in RF have also been proposed to be important for individuals with trauma histories (Ensink & Mayes, 2010). In fact,

traumatized children tend to have a low RF and a critical therapeutic task for individuals with trauma seems to be improving their understanding of self and other. Accordingly, mentalization-based therapies have also been proposed for high-risk parent-child dyads with an early history of deprivation and/or trauma (e.g., Sadler, Slade & Mayes, 2006), and substance abusing parents (Suchman, Legow, DeCoste, Castiglione & Mayes, 2008; Pajulo, Suchman, Kalland, Sinkkonen, Helenius & Mayes, 2008).

To sum up, mentalization is a complex construct that can be broadly described as “the capacity to situate oneself as a mental subject within a world of other mental subjects” (Galgut, 2010, p. 916); it is a developmental achievement that implies the recognition that “having a mind mediates our experience of the world” (Fonagy et al., 2002, p. 3). Its conceptualization is rooted in psychoanalytic object relation theory and attachment theory, and the instrument mostly used to measure it is the Fonagy’s RF scale. Some mentalization-based therapies have also been proposed: The aim, usually, is to develop – intersubjectively in and through the relationship with the therapist – the ability to better understand the thoughts and feelings of self and others.

### ***Mentalization and Psychological Mindedness:***

#### ***Clinical Perspective***

A concept conceptually close to that of mentalization (Allen & Fonagy, 2006), in which self-reflection and metacognition are key facets (Grant, 2001), is the construct of psychological mindedness (PM).

Originally, PM was defined as “a person’s ability to see relationships among thoughts, feelings, and actions, with the goal of learning the meanings and causes of his experience and behavior” (Appelbaum, 1973, p. 36). Afterward, different definitions have been proposed: Gough (1957/1975) defined the psychologically minded person as one who is “interested in, and responsive to, the inner needs, motives, and experiences of others” (p. 11); Farber (1985) stressed the role of psychological awareness and referred to PM as the “disposition to reflect upon the meaning and motivation of behavior, thoughts, and feelings of oneself and others” (p. 170); McCallum and Piper (1990) also incorporated aspects such as relating one’s intrapsychic components to one’s difficulties in the definition of PM; Conte, Buckley, Picard, and Karasu (1995) then included motivation and capacity for behavioral change, and interest in the motivation of other people’s behavior in their conceptualization of PM . In the light of all these elaborations, aiming to extract the core of PM and clarify its definition, Hall (1992) identified two main components of the construct: interest in and ability for reflecting on one’s psychological states and processes.

The concept of PM originally arose in psychodynamic thinking (Appelbaum, 1973; Taylor, Bagby, & Parker, 1989), to describe an important precondition for insight-oriented therapy to be successful (Taylor, Bagby, & Parker, 1989). For a long time, its use has been confined to psychodynamically oriented psychotherapy practice (Taylor, Bagby, & Parker, 1989), but recently some cognitive features of PM have also been taken into account. Beitel, Ferrer, and Cecero (2004), for example, have argued that PM could also be seen as an index of cognitive functioning, in that it is associated with flexibility, sense of personal agency, and inclination toward realistic thinking. Accordingly, nowadays the importance of PM is also acknowledged for

other forms of psychotherapy, such as dialectical behavior therapy and cognitive behavior therapy (Björgvinsson & Hart, 2006; Lewis, 2006). Very recently, the role of PM has also been discussed in the field of behavioral medicine and health psychology (Denollet & Nyklíček, 2004).

In fact, some empirical data suggest that PM is positively related to health and mental wellbeing (Beitel & Cecero, 2003; Beitel, Ferrer, & Cecero, 2004), and to psychotherapy success in clinical populations (McCallum & Piper, 1990; Taylor, Bagby, & Parker, 1989). Also, because PM is associated with awareness of one's own psychological states, high PM is expected to be related to more adequate responses to stressors than low PM (Conte et al., 1995; Nyklíček & Denollet, 2009). Moreover, it has been reported that PM tend to develop in securely attached individuals (Alvarez, Farber, & Schonbar, 1998; Beitel & Cecero, 2003), thus one may predict high PM to be accompanied by a wide range of mature defenses – a protective factor in stressful moments. Nevertheless, it should be pointed out that overall only a few empirical data on PM is available, because of the lack both of consensus on the exact meaning and definition of PM, and of psychometrically sound and easy-to-use instruments.

Synthesizing, PM can be broadly described as a person's characteristic reflecting both an attitude and an ability to access to both one's own and other's thoughts and feelings, with the purpose to learn and understand the meanings and causes of his or her experience and behavior. The construct of PM, therefore, is linked to concepts such as insight, introspection, self-awareness, reflective function, mentalization, and empathy.

## ***Empathy***

As previously reviewed, ToM, mentalization and PM have often been related, to some extent, to the ability to understand and think about the thoughts and feelings of another human being. This, in turn, means that ToM mentalization and PM are related to the ability to look through the mental states of others at the world as they see it. Put simply, to ‘put oneself in another’s shoes’. Though from many different perspectives – and with several theoretical differences – such an ability has often been referred to as empathy.

Technically, the English term empathy was coined by Edward Bradner Titchener (1909) as an English translation of the German word *Einfühlung*, meaning “feeling in” or “feeling into”. A German art historian and philosopher named Robert Vischer used this German term for the first time, in 1873, to refer to the feelings elicited by works of art in the observer (Hunsdahl, 1967; Jackson, 1992). Years later, in 1897, a German psychologist-philosopher named Theodore Lipps used the same word – *Einfühlung* – to refer to the body’s conscious or unconscious motoric imitations of the other’s movement, posture, expression, and gesture; a mechanism, in his opinion, responsible for the phenomenon of shared feelings. This latter connotation had a great resonance in the field of psychology, and certainly also had a central role in the wording choice of Titchener. In fact, the term empathy – used by Titchener to translate the word *Einfühlung* – derives from the Greek word *Empatheia*, which means “appreciation of another person’s feelings” (Astin, 1967; Wispe, 1986). Titchener used it to broadly refer to the understanding of other human beings (Titchener, 1915).

During its relatively short history, the construct of empathy has been widely discussed, and often it has also been marked by ambiguity. This is especially true within the field of psychotherapy,

where, according to some authors (see for example Lane, 1986; Levy, 1997; Wispe, 1986), the term has often been used with different meanings by different authors (Hojat, 2007). However, despite this controversy, the relevance of the construct of empathy is with no doubt acknowledged by numerous approaches.

Freud (1905) referred to empathy as the process of putting ourselves into another's position. In his view, empathy has a central role in our understanding something about someone else that is foreign to our own ego (Freud, 1921). Rogers (1951) – one of the most influential clinicians who stressed on the importance of empathy in the clinical practice – referred to the “empathic understanding” as the act of assuming “the client's frame of reference” (p. 29). In his opinion, empathy is a necessary and sufficient condition for his client-centered approach. Kohut (1971, 1984, 1991), similarly, considered empathy mainly as a method of observation in the therapeutic context. According to Kohut, indeed, empathy has a central role in understanding the client's experience and, in turn, in the formulation of the appropriate interpretations to strengthen the structure of the self. Several other authors have treated empathy as well.

According to Clark (2007), indeed, there are at least 13 psychotherapeutic traditions that consider – with varying degrees of emphasis – the construct of empathy. Among them, two – namely, the person-centered therapy and the self psychology – attribute a critical function to the construct. At least four – namely, individual psychology, existential therapy, psychoanalytic therapy, and cognitive/cognitive-behavioral therapy – refer to the construct in a conceptually compatible way. For example, within the tradition of the individual psychology, Adler (1927) views empathy as the ability to identify with other people and understand them, and underscores that such an ability is a necessary precondition to understand the client in his or her



uniqueness. Within the cognitive therapy tradition, similarly, Beck, Rush, Shaw, and Emery (1979) wrote that empathy serves to understand and experience, to some degree, the patient's feelings, in that "by 'trying on' a patient's negative attitudes and cognitions, the empathic therapist can begin to develop an antidote or counter-argument to these negative ideas" (p. 47-48). In short, although some controversy does exist in terms of definition of what empathy is, a common ground for its conceptualization can also be found.

One of the main differences across diverse theoretical positions consists of which elements of empathy are more relevant. Some theorists believe that empathy is mainly a cognitive ability, and stress on the importance of activities such as perspective-taking and role-taking (see, for example, Deutsch & Madle, 1975; Gladstein, 1983; Goldstein & Michaels, 1985). Dymond (1949), for example, advocated that empathy is "the imaginative transposing of oneself into the thinking, feeling, and acting of another, and so structuring the world as he does" (p. 127). Some other theorists, instead, believe that empathy is primarily an emotional response. Within this position, some authors consider empathy as an emotional contagion and focus on the sharing of the same feelings, while others consider empathy as an emotional responsivity, and focus on the fact that emotion is experienced as a consequence of the observation of someone else's experience (Gladstein, 1983; Hoffman, 1977, 1984). There are also other authors, however, that believe that empathy involves both cognitive and affective components (Baron-Cohen & Wheelwright, 2004; Davis, 1994). Bennet (2001), for example, claimed that empathy is "a mode of relating in which one person comes to know the mental content of another, both affectively and cognitively, at a particular moment in time and as a product of the relationship that exists between them" (p. 7).

To sum up, empathy can be broadly described as the ability, and/or willingness, to 'put oneself in another's shoes'; it may involve experiencing, communication, and/or observation, and different theoretical orientations approach the construct with differences in the extent to which they emphasize the importance of cognitive and/or affective components.

### ***Mirror Neurons and Embodied Simulation***<sup>5</sup>

In recent years, the interest in empathy has dramatically increased as a result of some advances in neuroscience, that allowed researchers to hypothesize a relationship between empathy and specific neural networks. More in detail, it has been suggested that empathy may find a neurobiological substrate in the neural matching mechanism constituted of a specific set of cells named mirror neurons (Gallese, 2001, 2003).

Technically speaking, mirror neurons are cortical brain cells that fire during both the execution and the observation of action and were discovered during single cell recording in the ventral premotor cortex (F5) of macaque monkeys that either performed an action or observed the same action performed by another monkey or an experimenter (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese,

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<sup>5</sup> This section consists of a partial reprint of the following published article, in which the dissertation author was first author: Giromini, L., Porcelli, P., Viglione, D., Parolin, L., & Pineda, J. (2010). The feeling of movement: EEG evidence for mirroring activity during the observations of static, ambiguous stimuli in the Rorschach cards. *Biological Psychology*, 85, 233-241. This article is Copyright © 2010, Elsevier. Reprinted with permission of the publisher and of the other authors.

Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). Single-unit recording is not typically performed in the human brain (although see Mukamel, Ekstrom, Kaplan, Iacoboni & Fried, 2010). Nonetheless, indirect population-level measures support the existence of a functional analogous system to macaque mirror neuron system (MNS) in the human inferior frontal gyrus (IFG) (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Iacoboni, Woods, Brass, Bekkering, Mazziotta & Rizzolatti, 1999) through transcranial magnetic stimulation (TMS) (Fadiga et al., 1995; Maeda, Kleiner-Fisman, & Pascual-Leone, 2002; Strafella & Paus, 2000), positron emission tomography (PET) (Parsons et al., 1995), functional magnetic resonance imaging (fMRI) (Buccino et al., 2004; Grézes, Armony, Rowe, & Passingham, 2003; Iacoboni et al., 1999; Rizzolatti et al., 1996), and electroencephalography (EEG) (Cochin, Barthelemy, Lejeune, Roux, & Martineau, 1998; Muthukumaraswamy & Johnson, 2004; Oberman, McCleery, Ramachandran, & Pineda, 2007; Oberman, Pineda, & Ramachandran, 2007; Pineda, Allison, & Vankov, 2000; Pizzamiglio et al., 2005; Rizzolatti, Fogassi, & Gallese, 2001). Further, data are consistent with the idea that the frontal MNS in humans may be part of a broader network of brain regions including the inferior parietal lobule (Buccino et al., 2001; Parsons et al., 1995), the superior temporal sulcus (Iacoboni et al., 2001), sensorimotor cortex (Pineda, 2008), and regions of the limbic system (Morrison, Lloyd, di Pellegrino, & Roberts, 2004; Singer, Seymour, O'Doherty, Kaube, Dolan & Frith, 2004; Wicker, Keysers, Plailly, Royet, Gallese & Rizzolatti, 2003). This broader network suggests that the MNS may play a more sophisticated role than pure imitation. It is speculated that the human MNS represents not only the physical aspects of an action but also the underlying intentions, thoughts, and feelings that motivated that action, therefore providing the neural basis for unique human social skills such

as empathy, ToM, mentalization, and facial emotion processing (Gallese, 2001; Gallese, 2006; Gallese & Goldman, 1998; Pelphrey & Morris, 2006; Uddin, Iacoboni, Lange, & Keenan, 2007) that allow effective social cognitive processes and interactions.

More in detail, it has been proposed that the human capacity to pre-rationally make sense of the actions, emotions and sensations of others depends on “embodied simulation”, a functional mechanism through which the actions, emotions, or sensations we see activate our own internal representations of the body states that are associated with these social stimuli, as if we were engaged in a similar action or experiencing a similar emotion or sensation (Freedberg & Gallese, 2007). Based on the MNS process, Gallese speculated that this “shared manifold of intersubjectivity” allows us to recognize other human beings who are similar to us (Gallese, 2003). Accordingly, it has been hypothesized that understanding the feelings and thoughts of other human beings may find a neurological substrate in the MNS.

Support for this position comes from the findings in social cognition – i.e., a broad concept that refers to the cognitive and brain processes that subserve behavior in response to conspecifics (i.e., other individuals of the same species) (Adolphs, 1999). Indeed, there is extensive theoretical discussion concerning the role of the MNS in social cognition (Agnew, Bhakoo, & Puri, 2007; Gallese & Goldman, 1998; Iacoboni & Dapretto, 2006; Rizzolatti & Craighero, 2004; Williams, Whiten, Suddendorf, & Perrett, 2001), and empirical evidence to date supports this link. For example, MNS activation is reduced among clinical populations for which social cognitive deficits represent a core feature (e.g., autism) (Hadjikhani, Joseph, Snyder, & Tager-Flusberg, 2006; Oberman, Hubbard, McCleery, Altschuler, Ramachandran & Pineda, 2005). Crucially, a number of authors have recently begun to investigate in healthy populations the proposed link

between the MNS and social cognitive functions such as empathy (Gazzola, Aziz-Zadeh, & Keysers, 2006; Kaplan & Iacoboni, 2006; Pfeifer, Iacoboni, Mazziotta, & Dapretto, 2008) and facial emotion processing (Enticott, Johnston, Herring, Hoy, & Fitzgerald, 2008; Sato & Yoshikawa, 2007; Wicker et al., 2003). The premotor MNS areas appear to be recruited not only for understanding the purpose or goal of an action, but also in the interpretation of the intention and the meaning of an action. It is not surprising, therefore, that the MNS has been implicated in disorders, such as autism spectrum disorders and schizophrenia, in which deficits of social cognition are one of the primary core features (Buccino & Amore, 2008; Dapretto et al., 2005; Oberman et al., 2005).

Synthesizing, understanding the feelings and thoughts of another human being seems to rely – at least in part – on a mirror-matching mechanism named embodied simulation. Empirical data suggest that such a mechanism finds a neurobiological substrate in the MNS.

### ***Purpose, Rationale, and Hypothesis***

As reviewed at the beginning of the chapter, the Rorschach literature indicates that the production of human movement (M) responses to the Rorschach test is strongly linked to the individual's ability and tendency to evoke an internal experience of human movement from an ambiguous stimulus and to involve this experience of movement in the perceptual processing of static pictures. Thus, because of the implied ability to identify with and think about human beings, the psychological process eliciting M responses resembles

theoretical constructs such as *Einführung*<sup>6</sup>, empathy, mentalization, and embodied simulation<sup>7</sup>. Accordingly, for almost 100 years the M response to the Rorschach test has been considered to be a demonstration of higher cognitive functioning (because it involves the integration of different perceptual features and individual psychological involvement), creativity (because the actual stimuli do not move), and ability to understand and think about human beings and human relationships (because of the implied ability to identify with and think about other human beings).

In this first chapter, it has also been reported that the human capacity to pre-rationally make sense of the actions, emotions and sensations of others depends on embodied simulation, and that a growing body of studies supports the “shared manifold hypothesis” that the brain substrate linking the bridge between embodied simulation and *Einführung*, empathy, and mentalization may be constituted by the mirror neuron system (MNS, Gallese, 2001).

Hence, if the link between the M responses to the Rorschach stimuli and embodied simulation, from one side, and the link between embodied simulation and the MNS, from the other side, held true, then it could be hypothesized that the Rorschach-based M responses may be associated with the activation of mirror neurons.

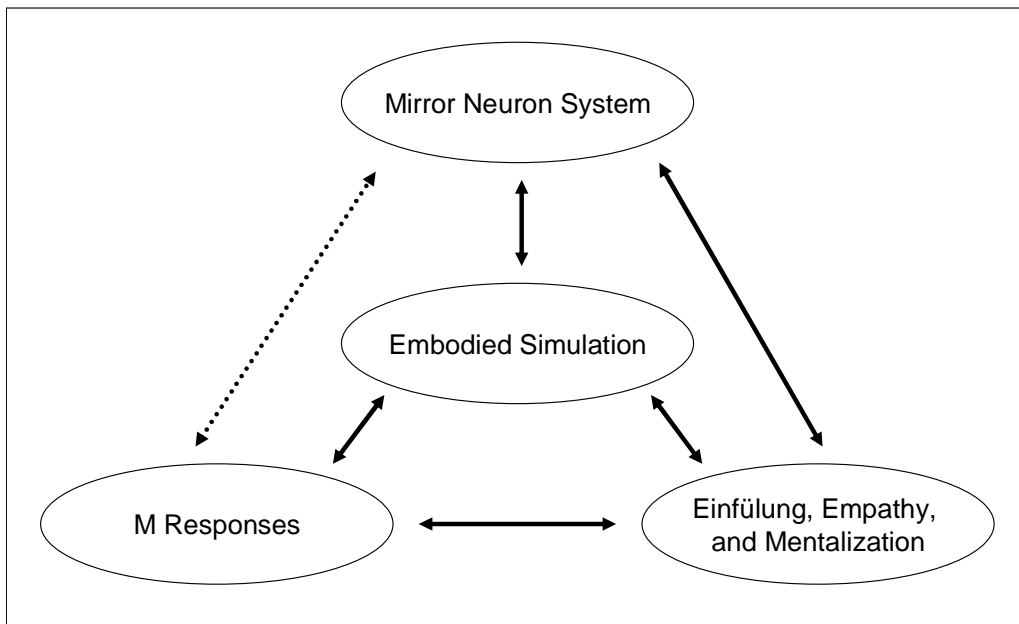
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<sup>6</sup> As reviewed above, *Einführung* is a German term meaning literally “feeling in” or “feeling into”, which has originally been used in the experience of art indicating the immediate physical responses generated in the observer by the exposure to art painting.

<sup>7</sup> As reviewed above, the term embodied simulation refers to a functional mechanism through which the actions, emotions, or sensations we see activate our own internal representations of the body states that are associated with these social stimuli, as if we were engaged in a similar action or experiencing a similar emotion or sensation (Freeberg & Gallese, 2007).

The purpose of this work is to investigate such association (see Fig. 1).

**Fig. 1. Graphical Representation of the Main Hypothesis of the Investigation**



The literature suggests that the production of M responses to the Rorschach test is linked to the constructs of embodied simulation, *einfühlung*, empathy, and mentalization. Given that such constructs are thought to be related to the activation of the mirror neuron system (MNS), the main hypothesis of this investigation is that M responses are related to the MNS as well.

## References

- Adler, A. (1927). *Understanding human nature* (W. B. Wolfe, Trans.). New York: Greenberg.
- Adolphs, R. (1999). Social cognition and the human brain. *Trends in Cognitive Science*, 3, 469-479.
- Agnew, Z. K., Bhakoo, K. K., & Puri, B. K. (2007). The human mirror system: A motor resonance theory of mind-reading. *Brain Research Reviews*, 54, 286-293.
- Ainsworth, M. S., Blehar, M. C., Waters, E., & Wall, S. (1978). *Patterns of Attachment: A Psychological Study of the Strange Situation*. Hillsdale, NJ: Erlbaum.
- Allen, J., & Fonagy, P. (Eds.). (2006). *Handbook of mentalization-based treatment*. West Sussex: John Wiley and Sons.
- Alvarez, J. R., Farber, B. A., & Schonbar, R. A. (1998). The relationship of psychological mindedness to adult perceptions of early parental rejection. *Journal of Clinical Psychology*, 54, 1079–1084.
- Appelbaum, S. A. (1973). Psychological-mindedness: Word, concept and essence. *International Journal of Psychoanalysis*, 54, 35–46.
- Astin, H. S. (1967). Assessment of empathic ability by means of a situational test. *Journal of Counseling Psychology*, 14, 57-60.
- Astington, J., & Gopnik, A. (1991). Developing understanding of desire and intention. In: Natural theories of mind: *The evolution, development and simulation of second order mental representations*, ed. A. Whiten. Oxford, UK: Basil Blackwell, pp. 39–50.
- Baldwin, J. M. (1906). *Social and Ethical Interpretations in Mental Development (4th ed.)*. London: Macmillan.



- Baron-Cohen, S. (1988). Social and pragmatic deficits in autism: Cognitive or affective?. *Journal of Autism and Developmental Disorders*, 18 (3), 379–403.
- Baron-Cohen, S. (1991). The theory of mind deficit in autism: How specific is it?. *British Journal of Developmental Psychology*, 9, 301–314.
- Baron-Cohen, S., & Swettenham, J. (1996). The relationship between SAM and ToMM: Two hypotheses. In: *Theories of theories of mind*, eds. P. Carruthers & P. K. Smith. Cambridge, UK: Cambridge University Press, pp. 158–168.
- Baron-Cohen, S., & Wheelwright, S. (2004). The empathy quotient: An investigation of adults with Asperger syndrome or high functioning autism, and normal sex differences. *Journal of Autism and Developmental Disorders*, 34, 163-175.
- Baron-Cohen, S., Jolliffe, T., Mortimore, C., & Robertson, M. (1997). Another advanced test of theory of mind: Evidence from very high functioning adults with autism or Asperger syndrome. *Journal of Child Psychology and Psychiatry*, 13, 813–822.
- Baron-Cohen, S., Leslie, A., & Frith, U. (1986). Mechanical, behavioural and intentional understanding of picture stories in autistic children. *British Journal of Developmental Psychology*, 4, 113–125.
- Baron-Cohen, S., Wheelwright, S., Hill, J., Raste, Y., & Plumb, I. (2001). The “Reading the mind in the eyes” Test–revised version: A study with normal adults, and adults with Asperger syndrome or high-functioning autism. *Journal of Child Psychology and Psychiatry*, 42(2), 241–251.
- Bateman, A. W., & Fonagy, P. (2004). *Psychotherapy for Borderline Personality Disorder: Mentalization Based Treatment*. Oxford: Oxford University Press.

- Beck, A. T., Rush, A. J., Shaw, B. F., & Emery, G. (1979). *Cognitive therapy of depression*. New York: Guilford.
- Beck, S. J. (1944). *Rorschach's test. Vol. I. Basic processes*. New York: Grune & Stratton.
- Beitel, M., & Cecero, J. J. (2003). Predicting psychological mindedness from personality style and attachment security. *Journal of Clinical Psychology, 59*, 163–172.
- Beitel, M., Ferrer, E., & Cecero, J. C. (2004). Psychological mindedness and cognitive style. *Journal of Clinical Psychology, 60*, 567–582.
- Bendick, M. R., & Klopfer, W. G. (1964). The effects of sensory deprivation and motor inhibition on Rorschach movement responses. *Journal of projective techniques and personality assessment, 28*, 261-264.
- Bennett, M. J. (2001). *The empathic healer: An endangered species*. San Diego: Academic Press.
- Björgvinsson, T., & Hart, J. (2006). Cognitive behavioral therapy promotes mentalizing. In J. G. Allen & P. Fonagy (Eds.), *Handbook of mentalization-based treatment* (pp. 157–170). Chichester, England: Wiley.
- Bleiberg, E., Fonagy, P., & Target, M. (1997). Child psychoanalysis: Critical overview and a proposed reconsideration. *Psychiatric Clinics of North America, 6*, 1–38.
- Bouchard, M. A., Lecours, S., Tremblay, L. M., Target, M., Fonagy, P., & Schachter, A. (2008). Mentalization in adult attachment narratives: Reflective functioning, mental states, and affect elaboration compared. *Psychoanalytic Psychology, 25*, 47–66.
- Bretherton, I. (1991). Intentional communication and the development of an understanding of mind. In: *Children's theories of mind: Mental*

- states and social understanding*, eds. D. Frye & C. Moore. Hilldale, NJ: Lawrence Erlbaum Associates, pp. 271–289.
- Brüne, M., & Brüne-Cohrs, U. (2005). Theory of mind-evolution, ontogeny, brain mechanisms and psychopathology. *Neuroscience & Biobehavioral Reviews*, *30*, 437-455.
- Buccino, G., & Amore, M. (2008). Mirror neurons and the understanding of behavioural symptoms in psychiatric disorders. *Current Opinion in Psychiatry*, *21*, 281-285.
- Buccino, G., Binkofski, F., Fink, G. R., Fadiga, L., Fogassi, L., Gallese, V., ... Freund, H. J. (2001). Action observation activates premotor and parietal areas in a somatotopic manner: An fMRI study. *European Journal of Neuroscience*, *13*, 400-404.
- Buccino, G., Vogt, S., Ritzl, A., Fink, G. R., Zilles, K., Freund, H. J., & Rizzolatti, G. (2004). Neural circuits underlying imitation learning of hand action: An event-related fMRI study. *Neuron* *42*, 323-334.
- Buitelaar, J. K., van der Wees, M., Swaab-Barneveld, H., & van der Gaag, R. J. (1999). Theory of mind and emotion-recognition functioning in autistic spectrum disorders and in psychiatric control and normal children. *Development and Psychopathology*, *11*, 39–58.
- Clark, A. J. (2007). *Empathy in counseling and psychotherapy: Perspectives and practices*. Mahwah, NJ: Erlbaum.
- Cochin, S., Barthelemy, B., Lejeune, S., Roux, J., & Martineau, J. (1998). Perception of motion and qEEG activity in human adults. *Electroencephalography and Clinical Neurophysiology*, *108*, 287-295.
- Conte, H. R., Buckley, P., Picard, S., & Karasu, T. B. (1995). Relationships between psychological mindedness and personality traits and ego functioning: Validity studies. *Comprehensive Psychiatry*, *36*, 11–17.

- Dapretto, M., Davies, M. S., Pfeifer, J. H., Scott, A. A., Sigman, M., Bookheimer, S. Y., & Iacoboni, M. (2005). Understanding emotions in others: Mirror neuron dysfunction in children with autism spectrum disorders. *Nature Neuroscience*, *9*, 28-30.
- Davis, M. H. (1994). *Empathy: A social psychological approach*. Boulder, CO: Westview.
- Dennett, D. C. (1987). *The Intentional Stance*. Cambridge, MA: MIT Press.
- Denollet, J., & Nyklíček, I. (2004). Psychological mindedness: A forgotten emotion-focused coping style?. In I. Nyklíček, L.R. Temoshok, & A.J.J.M. Vingerhoets (Eds.), *Emotional expression and health: Advances in theory, assessment and clinical applications* (pp. 185–203). London: Brunner-Routledge.
- Deutsch, F., & Madle, R. A. (1975). Empathy: Historic and current conceptualizations, and a cognitive theoretical perspective. *Human Development*, *18*, 267-287.
- Di Nuovo, S., Laicardi, C., & Tobino, C. (1988). Rorschach indices for discriminating between two schizophrenic syndromes. *Perceptual and Motor Skills*, *67*, 399-406.
- di Pellegrino, G., Fadiga, L., Fogassi, L., Gallese, V., & Rizzolatti, G. (1992). Understanding motor events: A neurophysiological study. *Experimental Brain Research*, *91*, 176-180.
- Dymond, R. F. (1949). A scale for the measurement of empathic ability. *Journal of Consulting Psychology*, *13*, 27-33.
- Ensink, K., & Mayes, L. C. (2010) The development of mentalisation in children from a theory of mind perspective. *Psychoanalytic Inquiry*, *30*, 301-337.
- Enticott, P. G., Johnston, P. J., Herring, S. E., Hoy, K. E., & Fitzgerald, P. B. (2008). Mirror neuron activation is associated with facial emotion processing. *Neuropsychologia*, *46*, 2851-2854.

- Exner, J. E. (1969). *The Rorschach systems*. New York: Grune & Stratton.
- Exner, J. E., & Andronikof-Sanglade, A. (1992). Rorschach changes following brief and short- term therapy. *Journal of Personality Assessment*, 59, 59-71.
- Exner, J. E., Jr (2003). *The Rorschach. A Comprehensive System. Vol. 1. Basic foundations and principles of interpretation (4th edn)*. New York: John Wiley & Sons.
- Fadiga, L., Fogassi, L., Pavesi, G., & Rizzolatti, G. (1995). Motor facilitation during action observation: A magnetic stimulation study. *Journal of Neurophysiology*, 73, 2608-2611.
- Farber, B. A. (1985). The genesis, development, and implications of psychological mindedness in psychotherapists. *Psychotherapy*, 22, 170–177.
- Ferracuti, S., Cannoni, E., Burla, F., & Lazzari, R. (1999). Correlations for the Rorschach with the Torrance tests of creative thinking. *Perceptual and Motor Skills*, 89, 863-870.
- Fodor, J. A. (1987). *Psychosemantics*. Cambridge, MA: MIT Press.
- Fonagy, P., & Target, M. (1996). Playing with reality: I. Theory of mind and the normal development of psychic reality. *International Journal of Psychoanalysis*, 77, 217–223.
- Fonagy, P., & Target, M. (2000). Mentalization and personality disorder in children: A current perspective from the Anna Freud Centre. In: Lubbe T, editor. *The borderline psychotic child: A selective integration*, 69–89. London: Routledge.
- Fonagy, P. (1997). Attachment and theory of mind : Overlapping constructs?. *Association for Child Psychology and Psychiatry, Occasional papers*, 14, 31–40.

- Fonagy, P., & Target, M. (1997). Attachment and reflective function: Their role in self-organisation. *Development and Psychopathology*, 9, 679–700.
- Fonagy, P., Gergely, G., Jurist, E. L., & Target, M. (2002). *Affect regulation, mentalization, and the development of the self*. New York, NY: Other Press.
- Fonagy, P., Leigh, T., Steele, M., Steele, H., Kennedy, R., Mattoon, G., Target, M., & Gerber A (1996). The relation of attachment status, psychiatric classification, and response to psychotherapy. *Journal of Consulting & Clinical Psychology*, 64, 22–31.
- Fonagy, P., Steele, H., & Steele, M. (1991). Maternal representations of attachment during pregnancy predict the organization of infant–mother attachment at one year of age. *Child Development*, 62, 891–905.
- Fonagy, P., Steele, H., Moran, G., Steele, M., & Higgitt, A. (1991). The capacity for understanding mental states: the reflective self in parent and child and its significance for security of attachment. *Infant Mental Health Journal*, 13, 200-217.
- Fonagy, P., Steele, M., Steele, H., Leigh, T., Kennedy, R., Mattoon, G., & Target, M. (1995). Attachment, the reflective self, and borderline states: The predictive specificity of the Adult Attachment Interview and pathological emotional development. In *Attachment Theory: Social, Developmental and Clinical Perspectives*, ed. S. Goldberg, R. Muir, & J. Kerr. New York: Analytic Press, pp. 233–278.
- Freeberg, D., & Gallese, V. (2007). Motion, emotion and empathy in esthetic experience. *Trends in Cognitive Science*, 11, 197-203.
- Freud, S. (1905). Jokes and their relation to the unconscious. In J. Strachey (Ed.), *The Standard Edition of the Complete Psychological Works of Sigmund Freud*, 8 (pp. 9-236). London: The Hogarth Press and the Institute of Psycho-Analysis.

- Freud, S. (1921). Group Psychology and the Analysis of the Ego. In J. Strachey (Ed.), *The Standard Edition of the Complete Psychological Works of Sigmund Freud*, 18 (pp. 65-143). London: The Hogarth Press and the Institute of Psycho-Analysis.
- Galgut, E. (2010). Reading minds: Mentalization, irony and literary engagement. *The International Journal of Psychoanalysis*, 91, 915–935
- Gallese, V. (2001). The ‘shared manifold hypothesis’: From mirror neurons to empathy. *Journal of Consciousness Studies*, 8, 33-50.
- Gallese, V. (2003). The roots of empathy: the shared manifold hypothesis and the neural basis of intersubjectivity. *Psychopathology*, 36, 171-180.
- Gallese, V. (2006). Intentional attunement: A neurophysiological perspective on social cognition and its disruption in autism. *Brain Research*, 1079, 15-24.
- Gallese, V., & Goldman, A. (1998). Mirror neurons and the simulation theory of mind-reading. *Trends in Cognitive Science*, 2, 493-501.
- Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, 119, 593-609.
- Gallucci, N. T. (1989). Personality assessment with children of superior intelligence: divergence versus psychopathology. *Journal of Personality Assessment*, 53, 749-760.
- Gazzola, V., Aziz-Zadeh, L., & Keysers, C. (2006). Empathy and the somatotropic auditory mirror system in humans. *Current Biology*, 16, 1824-1829.
- George, C., Kaplan, N., & Main, M. (1985). *The Adult Attachment Interview*. Unpublished manuscript, Department of Psychology, University of California.

- Gladstein, G. A. (1983). Understanding empathy: Integrating counseling, developmental, and social psychology perspectives. *Journal of Counseling Psychology, 30*, 467-482.
- Goldstein, A. P., & Michaels, G. Y. (1985). *Empathy: Development, training, and consequences*. Hillsdale, NJ: Erlbaum.
- Gordon, R. M. (1992). Folk psychology: Simulation or tacit theory?: Reply to Stich and Nichols. *Mind and Language, 7*(1-2), 87-97.
- Gough, H. (1957/1975). *California Psychological Inventory*. Palo Alto, CA: Consulting Psychologists Press.
- Grant, A. M. (2001). Rethinking psychological mindedness: Metacognition, self-reflection, and insight. *Behavior Change, 18*, 8-17.
- Greenwald, D. F. (1991). Personality dimensions reflected by the Rorschach and the 16PF. *Journal of Clinical Psychology, 47*, 708-715.
- Grézes, J., Armony, J. L., Rowe, J., & Passingham, R. E. (2003). Activations related to "mirror" and "canonical" neurons in the human brain: An fMRI study. *NeuroImage, 18*, 928-937.
- Grienenberger, J., Kelly, K., & Slade, A. (2005). Maternal reflective functioning, mother-infant affective communication, and infant attachment: Exploring the link between mental states and observed caregiving behavior in the intergenerational transmission of attachment. *Attachment & Human Development, 7*, 299-311.
- Hadikhani, N., Joseph, R. M., Snyder, J., & Tager-Flusberg, H. (2006). Anatomical differences in the mirror neuron system and social cognitive network in autism. *Cerebral Cortex, 16*, 1276-1282.
- Hall, J. A. (1992). Psychological-mindedness: A conceptual model. *American Journal of Psychotherapy, 46*, 131-140.



- Harris, P. L., Johnson, C. N., Hutton, D., Andrews, G., & Cooke, T. (1989). Young children's theory of mind and emotion. *Cognition and Emotion*, 3, 379–400.
- Harter, S. (1999). *The Construction of the Self: A Developmental Perspective*. New York: Guilford.
- Hix, M., Ebner, D. L., Stanford, M. S., Pantle, M., Kerr, J. A., & Patton, J. H. (1994). The Rorschach and personality classifications of the California Psychological Inventory. *Perceptual and Motor Skills*, 78, 142.
- Hoffman, M. L. (1977). Sex differences in empathy and related behaviors. *Psychological Bulletin*, 84, 712-722.
- Hoffman, M. L. (1984). Interaction of affect and cognition in empathy. In C. E. Izard, J. Kagan, & R. B. Zajonc (Eds.), *Emotions, cognition, and behavior* (pp. 103-131). Cambridge: Cambridge University Press.
- Hojat, M. (2007). *Empathy in patient care: Antecedents, development, measurement, and outcomes*. New York: Springer.
- Hunsdahl, J. B. (1967). Concerning Einfühlung (empathy): A concept analysis of its origin and early development. *Journal of History of the Behavioral Sciences*, 3, 180-191.
- Iacoboni, M., & Dapretto, M. (2006). The mirror neuron system and the consequences of its dysfunction. *Nature Reviews Neuroscience*, 7, 942-951.
- Iacoboni, M., Koski, L. M., Brass, M., Bekkering, H., Woods, R. P., Dubeau, M. C., ... Rizzolatti, G. (2001). Reafferent copies of imitated actions in the right superior temporal cortex. *Proceedings of the National Academy of Sciences*, 98, 13995-13999.
- Iacoboni, M., Woods, R. P., Brass, M., Bekkering, H., Mazziotta, J. C., & Rizzolatti, G. (1999). Cortical mechanisms of human imitation. *Science*, 286, 2526-2528.

- Jackson, S. W. (1992). The listening healer in the history of psychological healing. *American Journal of Psychiatry*, 149, 1623-1632.
- Kaplan, J. T., & Iacoboni, M. (2006). Getting a grip on other minds: Mirror neurons, intention understanding, and cognitive empathy. *Social Neuroscience*, 1, 175-183.
- Klopfer, B., & Kelley, D. M. (1942). *The Rorschach technique*. Yonkers-on-Hudson, NY: World Books.
- Kohut, H. (1971). *Analysis of the self: A systematic approach to the psychoanalytic treatment of narcissistic personality disorders*. New York: International University Press.
- Kohut, H. (1984). Introspection, empathy, and the semicircle of mental health. In J. Lichtenberg, M. Bornstein, & D. Silver (Eds.), *Empathy* (Vol. 1, pp. 81-100). Hillsdale, NJ: Erlbaum.
- Kohut, H. (1991). On empathy. In P. H. Ornstein (Ed.), *The search for the self: Selected writings of Heinz Kohut: 1978-1981* (Vol. 4, pp. 525-535). Madison, CT: International University Press.
- Lane, F. E. (1986). Utilizing physician empathy with violent patients. *American Journal of Psychotherapy*, 40, 448-456.
- Leslie, A. M. (1986). Getting development off the ground: Modularity and the infant's perception of causality. In: *Theory building in developmental psychology*, ed. P. L. vanGeert. Amsterdam: Elsevier Science, pp. 110–137.
- Leslie, A. M. (1987). Pretence and representation: The origins of 'theory of mind'. *Psychological Review*, 94, 412–426.
- Levy, J. (1997). A note on empathy. *New Ideas in Psychology*, 15, 179-184.
- Lewis, D. (1966). An argument for the identity theory. *Journal of Philosophy*, 63, 17–25.

- Lewis, L. (2006). Enhancing mentalizing capacity through dialectical behavior therapy skills training and positive psychology. In J. G. Allen & P. Fonagy (Eds.), *Handbook of mentalization-based treatment* (pp. 171–182). Chichester, England: Wiley.
- Lipps, T. (1903). Einföhlung, innere nachahmung und organenempfindung. *Archiv. F. die Ges. Psychologie*, 1, part 2 (Leipzig: W. Engelmann).
- Maeda, F., Kleiner-Fisman, G., & Pascual-Leone, A. (2002). Motor facilitation while observing hand actions: Specificity of the effect and role of observer's orientation. *Journal of Neurophysiology*, 87, 1329-1335.
- Malmgren, H. (2000). Rorschach's Idea of a Movement Response in the Light of Recent Philosophy and Psychology of Perception. *Rorschachiana*, 24(1), 1-27.
- Mayman, M. (1977). A multi-dimensional view of the Rorschach movement response: perception, fantasy, kinesthesia, self-representation, and object-relationships. In M. A. Rickers-Ovsiankina (Ed.), *Rorschach psychology*. Huntington, NY Krieger. Pp. 229-250.
- McCallum, M., & Piper, W. E. (1990). The Psychological Mindedness Assessment Procedure. *Psychological Assessment*, 2, 412–418.
- McCallum, M., & Piper, W. E. (1997). The psychological mindedness assessment procedure. In M. McCallum & W.E. Piper (Eds.), *Psychological mindedness: A contemporary understanding* (pp. 27–58). Mahwah, NJ: Erlbaum.
- Meins, E., Fernyhough, C., Fradley, F., & Tuckey, M. (2001). Rethinking maternal sensitivity: Mothers' comments on infant's mental processes predict security of attachment at 12 months. *Journal of Child Psychology and Psychiatry*, 42, 637–648.

- Meins, E., Fernyhough, C., Russell, J., & Clark-Carter, D. (1998). Security of attachment as a predictor of symbolic and mentalising abilities: a longitudinal study. *Social Development, 7*(1), 1–24.
- Meyer, G. J., Viglione, D. J., Mihura, J., Erard, R. E., & Erdberg, P. (2011). *Rorschach Performance Assessment System: Administration, coding, interpretation, and technical manual*. Toledo, OH: Rorschach Performance Assessment System.
- Morrison, I., Lloyd, D., di Pellegrino, G., & Roberts, N. (2004). Vicarious responses to pain in anterior cingulate cortex: Is empathy a multisensory issue?. *Cognitive Affective & Behavioral Neuroscience, 4*, 270-278.
- Mukamel, R., Ekstrom, A.D., Kaplan, J., Iacoboni, M., & Fried, I. (2010). Single-neuron responses in humans during execution and observation of actions. *Current Biology, 20*, 750-756.
- Muthukumaraswamy, S. D., & Johnson, B. W. (2004). Primary motor cortex activation during action observation revealed by wavelet analysis of the EEG. *Clinical Neurophysiology, 115*, 1760-1766.
- Nyklíček, I., & Denollet, J. (2009). Development and evaluation of the Balanced Index of Psychological Mindedness. *Psychological Assessment, 21*, 32–44.
- Oberman, L. M., Hubbard, E. M., McCleery, J. P., Altschuler, E. L., Ramachandran, V. S., & Pineda, J. A. (2005). EEG evidence for mirror neuron dysfunction in autism spectrum disorders. *Cognitive Brain Research, 24*, 190-198.
- Oberman, L. M., McCleery, J. P., Ramachandran, V. S., & Pineda, J. A. (2007). EEG evidence for mirror neuron activity during the observation of human and robot actions: Toward an analysis of the human qualities of interactive robots. *Neurocomputing, 70*, 2194-2203.

- Oberman, L. M., Pineda, J. A., & Ramachandran, V. S. (2007). The human mirror neuron system: A link between action observation and social skills. *Social Cognitive and Affective Neuroscience*, *2*, 62-66.
- Orlinsky, D. E. (1966). Rorschach test correlates of dreaming and dream recall. *Journal of projective techniques and personality assessment*, *30*, 250-253.
- Pajulo, M., Suchman, N., Kalland, M., Sinkkonen, J., Helenius, H., & Mayes, L. C. (2008). Role of maternal reflective ability for substance abusing mothers. *Journal of Prenatal and Perinatal Psychology and Health*, *23*, 13–31.
- Parsons, L. M., Fox, P. T., Downs, J. H., Glass, T., Hirsch, T. B., Martin, ... Lancaster, J. L. (1995). Use of implicit motor imagery for visual shape discrimination as revealed by PET. *Nature*, *375*, 54-58.
- Pelphrey, K. A., & Morris, J. P. (2006). Brain mechanisms for interpreting the actions of others from biological motion cues. *Current Directions in Psychological Science*, *15*, 136-140.
- Perner, J., & Wimmer, H. (1985). 'John thinks that Mary thinks..'. Attribution of second-order beliefs by 5-10 year old children. *Journal of Experimental Child Psychology*, *39*, 437–471.
- Pfeifer, J. H., Iacoboni, M., Mazziotta, J. C., & Dapretto, M. (2008). Mirroring others' emotions relates to empathy and interpersonal competence in children. *NeuroImage*, *39*, 2076-2085.
- Pineda, J. A. (2008). Sensorimotor Cortex as a Critical Component of an 'Extended' Mirror Neuron System: Does it Solve the Development, Correspondence, and Control Problems in Mirroring?. *Behavioral and Brain Functions*, *4*, 47.
- Pineda, J. A., Allison, B. Z., & Vankov, A. (2000). The effects of self-movement, observation and imagination on mu rhythms and

- readiness potentials (RP's): Toward a brain-computer interface (BCI). *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 8, 219-222.
- Piotrowski, Z. A. (1957). *Perceptanalysis*. New York: Macmillan.
- Piotrowski, Z. A. (1977). The movement responses. In M. A. Rickers-Ovsiankina (Ed.), *Rorschach psychology*. Huntington, NY: Krieger. Pp. 189-227.
- Pizzamiglio, L., Aprile, T., Spitoni, G., Pitzalis, S., Bates, E., D'Amico, S., & Di Russo, F. (2005). Separate neural systems for processing action- or non-action-related sounds. *NeuroImage*, 24, 852-861.
- Porcelli, P., & Meyer, G. J. (2002). Construct validity of Rorschach variables for alexithymia. *Psychosomatics*, 43, 360-369.
- Porcelli, P., & Mihura, J. L. (2010). Assessment of alexithymia with the Rorschach Comprehensive System: The Rorschach Alexithymia Scale (RAS). *Journal of Personality Assessment*, 92 (2), 128 – 136.
- Premack, D., & Woodruff, G. (1978). Does the chimpanzee have a “theory of mind”? *Behavioral and Brain Sciences*, 1, 515–526.
- Rapaport, D., Gill, M., & Schafer, R. (1946). *Diagnostic psychological testing: The theory, statistical evaluation, and diagnostic application of a battery of tests*. Chicago: The Year book publishers, inc.
- Rhue, J. W., & Lynn, S. J. (1987). Fantasy proneness and psychopathology. *Journal of Personality and Social Psychology*, 53, 327-336.
- Rizzolatti, G., & Craighero, L. (2004). The mirror neuron system. *Annual Review of Neuroscience*, 27, 169-192.
- Rizzolatti, G., Fadiga, L., Gallese, V., & Fogassi, L. (1996). Premotor cortex and the recognition of motor actions. *Cognitive Brain Research*, 3, 131-141.

- Rizzolatti, G., Fogassi, L., & Gallese, V. (2001). Neurophysiological mechanisms underlying the understanding and imitation of action. *Nature Review Neuroscience*, 2, 661-670.
- Rogers, C. R. (1951). *Client-centered therapy: Its current practice, implications and theory*. Boston: Houghton-Mifflin.
- Rorschach, H. (1921). *Psychodiagnostik*. Bern: Bircher.
- Sadler, L. S., Slade, A., & Mayes, L. C. (2006), Minding the baby: A mentalisation based parenting program. In: *Handbook of mentalisation based treatment*, eds. J. G. Allen & P. Fonagy. New York: John Wiley and Sons, pp. 271–288.
- Sato, W., & Yoshikawa, S. (2007). Enhanced experience of emotional arousal in response to dynamic facial expressions. *Journal of Nonverbal Behavior*, 31, 119-135.
- Saxe, R., Carey, S., & Kanwisher, N. (2004). Understanding other minds: Linking developmental psychology and functional neuroimaging. *Annual Review of Psychology*, 55, 87–124.
- Singer, T., Seymour, B., O'Doherty, J., Kaube, H., Dolan, R. J., & Frith, C. D. (2004). Empathy for pain involves the affective but not sensory components of pain. *Science*, 303, 1157-1162.
- Steele, N. M., & Kahn, M. W. (1969). Kinesthesia and the Rorschach M response. . *Journal of projective techniques and personality assessment*, 33, 5-10.
- Strafella, A. P., & Paus, T. (2000). Modulation of cortical excitability during action observation: A transcranial magnetic stimulation study. *Neuroreport*, 11, 2289-2292.
- Suchman, N., Legow, N., DeCoste, C., Castiglione, N., & Mayes, L. C. (2008). The mothers and toddlers program: preliminary findings from an attachment-based parenting intervention for substance-abusing mothers. *Psychoanalytic Psychology*, 25, 499–517.

- Sugarman, A. (2006). Mentalization, insightfulness, and therapeutic action: The importance of mental organization. *International Journal of Psychoanalysis*, *87*, 965–87.
- Taylor, G. J., Bagby, M., & Parker, J. (1989). Psychological-mindedness and the alexithymia construct. *British Journal of Psychiatry*, *154*, 731–732.
- Titchener, E. B. (1909). *Lectures on the experimental psychology of the thought-process*. New York: Macmillan.
- Titchener, E. B. (1915). *A beginner's psychology*. New York: Macmillan.
- Uddin, L. Q., Iacoboni, M., Lange, C., & Keenan, J. P. (2007). The self and social cognition: The role of cortical midline structures and mirror neurons. *Trends in Cognitive Sciences*, *11*, 153-157.
- Viglione, D. J. (1999). A review of recent research addressing the utility of the Rorschach. *Psychological Assessment*, *11*, 251–265.
- Viglione, D. J. (2002). *Rorschach coding solutions: A reference guide for the Comprehensive System*. San Diego: Donald J. Viglione.
- Watson, J. B. (1930). *Behaviorism (rev. ed.)*. New York: Norton.
- Weiner, I. B., & Exner, J. E., Jr. (1991). Rorschach changes in long-term and short-term psychotherapy. *Journal of Personality Assessment*, *56*, 453–465.
- Wellman, H. M. (1990). *The Child's Theory of Mind*. Cambridge, MA: Bradford Books.
- Wellman, H. M., & Lagattuta, K. H. (2000). Developing understandings of mind. In: *Understanding other minds*, eds. S. Baron-Cohen, H. Tager-Flusberg, & D. J. Cohen. London: Oxford University Press, pp. 45–72.
- Wicker, B., Keysers, C., Plailly, J., Royet, J. P., Gallese, V., & Rizzolatti, G. (2003). Both of us disgusted in my insula: The



- common neural basis of seeing and feeling disgust. *Neuron*, 40, 655-664.
- Williams, J. H. G., Whiten, A., Suddendorf, T., & Perrett, D. I. (2001). Imitation, mirror neurons and autism. *Neuroscience and Biobehavioral Reviews*, 25, 287-295.
- Wimmer, H., & Perner, J. (1983). Beliefs about beliefs: Representation and constraining function of wrong beliefs in young children's understanding of deception. *Cognition*, 13, 103–128.
- Wispe, L. (1986). The distinction between sympathy and empathy: To call forth a concept, a word is needed. *Journal of Personality and Social Psychology*, 50, 314-321.
- Witkin, H. A., Dyk, R. B., Faterson, H. F., Goodenough, D. R., & Karp, S. A. (1962). *Psychological differentiation*. New York: Wiley.
- Wood, J. M., Krishnamurthy, R., & Archer, R. P. (2003). Three factors of the Comprehensive System for the Rorschach and their relationship to Wechsler IQ scores in an adolescent sample. *Assessment*, 10, 259-265.
- Young, G. R., & Wagner, E. E. (1993). Behavioral specificity in the Rorschach human movement response: a comparison of strippers and models. *Journal of Clinical Psychology*, 49, 407-412.

## CHAPTER 2

### A First Pilot Study

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In the last few decades it has been proposed that the preactivation of certain areas of the cortex might 'prime' behaviors and competences that are related to such neural areas. One of the most famous examples of this phenomenon – also called 'neurological priming' – is probably the Mozart effect, which was discussed for the first time in a 1993 issue of *Nature*. In the study, Rauscher, Shaw, and Ky (1993) observed that brief exposure to Mozart's "Sonata for Two Pianos in D Major, K.448" led to higher short-term enhancement of spatial intelligence scores as compared to exposure to silence or a relaxation tape. These initial findings were later replicated or extended by the same authors (e.g., Rauscher & Shaw, 1998; Rauscher, Shaw, & Ky, 1995) and other researchers (e.g., Auon, Jones, Shaw, & Bodner 2005; Ho, Mason & Spence, 2007; Rauscher, Robinson, & Jens, 1998). According to Rauscher, Shaw, and Ky (1993), the higher spatial performance after exposure to Mozart's sonata might be the result of the music priming the brain for spatial activity. Indeed, both musical (Bever & Chiarello, 1974), spatial (De Renzi, 1982; Desrocher, Smith, & Taylor, 1995; Kimura, 1969), and attentional (Liederman, 1986; Mesulam, 1981) processing are thought to be associated with right hemisphere activation (Leng & Shaw, 1991). Thus, listening to Mozart's music might activate brain areas that are also involved in spatial processing, and this, in turn, might 'prime' spatial cognition such that spatial performance is improved.

Although there is some controversy (e.g., Newman, Rosenbach, Burns, Latimer, Matocha & Vogt, 1995; Steele, Ball, & Runk, 1997; Stough, Kerkin, Bates, & Mangan, 1994), such a 'neurological' explanation for the Mozart 'priming' effect is supported by several empirical data. First, listening to Mozart's music not only improves spatial performance but also affects brain functioning, as indicated by electroencephalography (EEG) recordings (Jausovec & Habe, 2005). In addition, not only spatial abilities but also visuo-spatial attention – another function of the right hemisphere – improves after listening to Mozart (Ho et al., 2007). Moreover, Rideout, Dougherty, and Wernert (1998) found that a similar effect to the Mozart effect could also be observed by using Yanni's "Acroyali/Standing in Motion", a musical composition deemed to be similar to the Mozart piece used in the first study. Furthermore, the Mozart effect occurs in non-musicians, who process melodic information exclusively in the right hemisphere, but not in musicians, who process melodic information in both hemispheres (Aheadi, Dixon, & Glover, 2009). Other evidence also supports this view (Chokron, Bartolomeo, Colliot, & Auclair, 2002; Coupard & Kapoula, 2005; Kittler & Turkewitz, 1999; Mildner, 2002).

The phenomenon of the 'neurological priming' finds a theoretical foundation in the trion model of the cortical column (Leng & Shaw, 1991; McGrann, Shaw, Silverman & Pearson, 1991; Shaw, Silverman & Pearson, 1985, 1988; Silverman, Shaw & Pearson, 1986), which is a mathematical representation of Mountcastle's (1978) columnar model of the cerebral cortex. Roughly speaking, the main idea of the model is that small units of neurons have different levels of firing activity, and different clusters of these units can produce complex spatial-temporal firing patterns. As a result, a change in a few units or clusters can affect broader patterns of spatial-temporal firing. In line with this model, similar units or clusters of neurons might fire, for example, when either

listening to music or doing activities requiring spatial ability (Leng & Shaw, 1991). Accordingly, listening to music might affect and 'prime' multiple patterns of spatial-temporal firing, including those that are related to the execution of tasks requiring spatial ability, i.e., hearing Mozart's music might 'warm-up' neurons prior to completing a spatial task, thus improving the performance (Rauscher, Shaw, & Ky, 1993).

The idea that preactivating specific cerebral regions might 'prime' functions related to such regions also comes from many other research areas. For example, Reuter-Lorenz, Kinsbourne and Moscovitch (1990) have shown that activating the left hemisphere by requiring to complete a verbal task leads to an improvement in other tasks processed by the left hemisphere, such as processing times or efficiency for information presented. As another example, Brunel, Lesourd, Labeye and Versace (2010), investigating the sensory priming effects in semantic categorization, have recently suggested that a facilitatory effect could be explained in terms of preactivation of auditory areas. A further example, Sterr (2006), working on the response-priming paradigm (Neumann & Klotz, 1994; Vorberg, Mattler, Heinecke, Schmidt, & Schwarzbach, 2003), has proposed that performance differences between response and no-response priming conditions may be due to different preactivations of motor regions evoked by the prime stimuli.

Many other examples could also be found, especially in research areas dealing with visuomotor priming and action imitation abilities (e.g., Gillmeister, Catmur, Brass & Heyes, 2008; Vogt, Taylor & Hopkins, 2003).

**Purpose, Rationale and Hypotheses.** In chapter 1 it has been stated that the main purpose of this study consists of investigating if the production of the human movement (M) response to the Rorschach test is linked to the activation of the mirror neuron system (MNS). In the

introductory section of this chapter (i.e., chapter 2), it has been reported that a growing body of research suggests that the preactivation of certain areas of the brain might facilitate the execution of tasks or behaviors that are modulated by similar cerebral areas. By putting together all this information, one may speculate that if the link between the production of M responses to the Rorschach and the activation of the MNS held true, then the preactivation of the MNS should affect the production of M responses. More in detail, it can be hypothesized that a preactivation of the MNS would result in an enhanced ability to produce M responses to the Rorschach cards.

To preliminarily investigate this hypothesis, a small sample of students were administered some Rorschach cards immediately after having showed them some short videos expected to activate the MNS at different levels. It was anticipated that if M responses to the Rorschach and MNS activity were associated, then the participants would produce more M responses when exposed to the videos that elicit higher activation of the MNS, as a result of a 'neurological priming'.

## ***Materials and Methods***

**Participants.** The sample was composed of 30 students of the University of Milano-Bicocca, ranging in age from 18 to 25 years ( $M = 22.6$ ;  $SD = 4.3$ ). Sixty percent ( $n = 18$ ) of them were female. Although they were college-level psychology students, nobody attended any Rorschach classes before volunteering for the experiment. Compensation for participation consisted of enrichment points credit in their class.

**Procedure.** After giving written consent for participation, each participant was individually taken into a quiet room to begin the experiment. Some short videos and Rorschach cards were then presented on a computer monitor. First, one of the videos was presented for 10 seconds, with the participant having only the instruction to observe it. Then a Rorschach card appeared, with the participant being asked to tell the experimenter what the inkblot might be. No time limit was given for responding. Once the participant verbalized his or her response, the experimenter transcribed it *verbatim*. Subsequently, another video started, followed by another Rorschach card, and so forth until the end of the experiment. Eventually, the experimenter inquired the responses according to the Rorschach Comprehensive System (Exner, 2003) method.

**Stimuli.** The stimuli consisted of three videos and three Rorschach cards. The videos were taken from Oberman, Pineda and Ramachandran (2007), with the purpose to activate the MNS of the participants at different levels. One video (A; baseline) consisted of a full-screen television static (mean luminance 3.7 cd/m<sup>2</sup>); one video (B; low MNS activation) showed three individuals tossing a ball up in the air to themselves; one video (C; high MNS activation) showed the same three individuals tossing a ball to each other and occasionally throwing the ball off the screen toward the viewer. According to Oberman et al., (2007), highest activation of MNS occurs for video C, followed by video B, followed by video A. Consequently, we anticipated that the participants would produce the highest number of M responses in condition C (i.e., after exposure to video C), followed by condition B (i.e., after exposure to video B), followed by condition A (i.e., after exposure to video A).

The subset of Rorschach cards was chosen to have a sufficient number of M responses without making the administration too long. Accordingly the three cards (card II, III, and VII) with the highest M responses frequency in the reference dataset (Exner & Erdberg, 2005) were selected. Each card was presented three times, one per condition – i.e., once after exposure to video A, once after exposure to video B and once after exposure to video C. Participants were required to give a different response per each card, such that in total each subject was asked to produce nine different Rorschach responses – three to each one of the three Rorschach cards per each condition.

The entire presentation order was randomized.

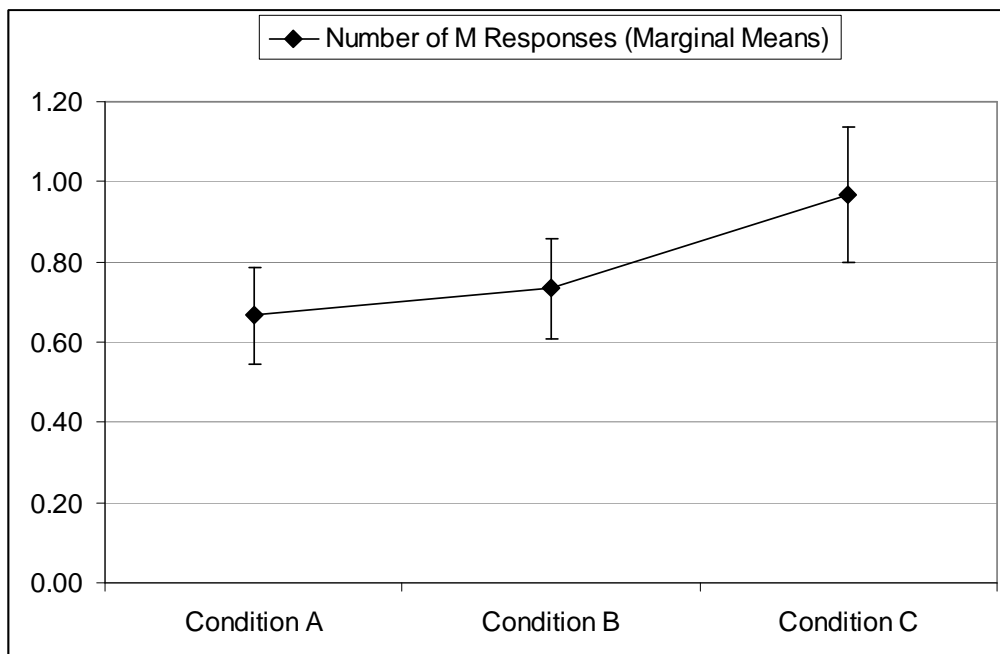
**Analysis.** To test the hypothesis that higher preactivation of MNS leads to greater production of M responses, the mean number of M responses produced in the three conditions (i.e., after exposure to video A, after exposure to video B, and after exposure to video C) was compared through repeated measures within subject ANOVA. The presence of a linear trend with the number of M being progressively higher from condition A to condition B to condition C was also tested.

## ***Results***

The mean number of M responses produced after exposure to videos A, B, and C was not significantly different,  $F(2,58) = 1.629$ ,  $p = .205$ ,  $\eta^2 = .053$ . However a linear trend indicating M as progressively more frequent from condition A to B to C was marginally significant, when a nonconservative threshold ( $\alpha = 0.10$ ) was considered,  $F(1,29) = 2.767$ ,  $p = .107$ ,  $\eta^2 = .087$  (Fig. 2). Also, the partial eta squared

values, for both the analyses, fell in the medium range of suggested benchmarks (small=0.01; medium=0.06; large=0.14) (Kittler, Menard & Phillips, 2007). Accordingly, one may speculate that with bigger sample sizes or higher number of stimuli the predicted effect could be observed.

**Fig. 2. Mean Number of M Responses after Exposure to Videos A, B, and C.**



Mean number of M responses produced after exposure to video A (baseline), B (low-MNS preactivation), and C (high-MNS preactivation). Error bars represent the standard error of the mean. The difference among the three conditions is not statistically significant.

## ***Discussion and Conclusion***



This pilot study aimed to preliminarily investigate the association between M responses to the Rorschach test and MNS activation. It was hypothesized that if such association held true then a preactivation of the MNS prior to exposure to the Rorschach stimuli would increase the production of M responses, because of a sort of ‘neurological priming’ phenomenon. Thus, three videos believed to activate the MNS at different levels were utilized, and the participants were administered a few Rorschach cards three times, each time after exposure to one of the videos. According to our hypotheses, it was expected that the mean number of M responses produced by the respondents in each condition (i.e., after exposure to each of the videos) would be linearly related to the level of MNS activation formerly elicited by the video.

The results did not fully confirm the hypotheses, i.e., no significant differences were found. However, within our small sample, the highest mean frequency of M responses was observed for condition C, i.e., for responses produced after exposure to the video associated with the highest MNS activation (see Fig. 2, condition C). Also, when a nonconservative threshold was considered a marginally significant linear trend in the expected direction was observed. Furthermore, the effect sizes were medium and in the expected direction. Finally, some methodological issues may have reduced the possibility to accurately detect the effects of a ‘neurological priming’. First, the same three videos were presented to all participants many times during the experiment. Therefore, it is possible that some sort of habituation processes occurred, thus reducing the ‘priming power’ of the videos. Second, not to make the administration too long, only three Rorschach stimuli were selected. As a result, per each condition the number of M responses that could theoretically be produced ranged from 0 to 3. Such a low variability may have reduced the possibility to measure precisely the effects of the neurological priming. Third, a confounding

variable of this study is the fact that the same Rorschach cards were administered three times. Indeed, given the small amount of data analyzed, it is not possible to untangle whether this perceptual specificity has had an impact on the results.

Accordingly, with a bigger sample size and a more appropriate research design the preactivation of the MNS could actually lead to a significant increase in the production of M responses. Hence, although this first pilot study does not strongly support that the activation of the MNS 'primes' the production of M responses, some data encourage continuing to investigate the main hypothesis that there is a relationship between the production of M responses to the Rorschach test and the activation of the MNS.

## References

- Aheadi, A., Dixon, P., & Glover, S. (2010). A limiting feature of the Mozart effect: Listening improves spatial cognition in non-musicians but not musicians", *Psychology of Music*, 38, 107-117.
- Aoun, P., Jones, T., Shaw, G. L., & Bodner, M. (2005). Long-term enhancement of maze learning in mice via a generalized Mozart effect. *Neurological Research*, 27, 791–796.
- Bever, T. G., & Chiarello, R. J. (1974). Cerebral dominance in musicians and nonmusicians. *Science*, 185, 137–139.
- Brunel, L., Lesourd, M., Labeye, E., & Versace, R. (2010). The sensory nature of knowledge : sensory priming effects in semantic categorisation. *Quarterly Journal of Experimental Psychology*, 63(5), 955-964.
- Chokron, S., Bartolomeo, P., Colliot, P., & Auclair, L. (2002). Effect of gaze orientation on tactile-kinesthetic performance. *Brain and Cognition*, 48, 312–317.
- Coupard, O. A., & Kapoula, Z. (2005). Inhibition of saccade and vergence eye movements in 3D space. *Journal of Vision*, 5, 1–19.
- De Renzi, E. (1982). *Disorders of space exploration and cognition*. Chichester: Wiley.
- Desrocher, M. E., Smith, M. L., & Taylor, M. J. (1995). Stimulus and sex differences in performance of mental rotation: Evidence from event-related potentials. *Brain and Cognition*, 28, 14–38.
- Exner, J. E., Jr (2003). *The Rorschach. A Comprehensive System. Vol. 1. Basic foundations and principles of interpretation (4th edn)*. New York: John Wiley & Sons.

- Exner, J. E., Jr., & Erdberg, P. (2005). *The Rorschach: A Comprehensive System. Vol.2. Advanced interpretation (3rd edn)*. New York: John Wiley & Sons.
- Gillmeister, H., Catmur, C., Brass, M., & Heyes, C. (2008). Experience-based priming of body parts: a study of action imitation. *Brain Research, 1217*, 157-170.
- Ho, C., Mason, O., & Spence, C. (2007). An investigation into the temporal dimension of the Mozart effect: Evidence from the attentional blink task. *Acta Psychologica, 125*, 117–128.
- Jausovec, N., & Habe, K. (2005). The influence of Mozart's sonata K. 448 on brain activity during the performance of spatial rotation and numerical tasks. *Brain Topography, 17*, 207–218.
- Kimura, D. (1969). Spatial localization in left and right visual fields. *Canadian Journal of Psychology, 23*, 445–458.
- Kittler, J. E., Menard, W., & Phillips, K. A. (2007). Weight concerns in individuals with body dysmorphic disorder. *Eating Behavior, 8*, 115-120.
- Kittler, P., & Turkewitz, G. (1999). The talking face: Effects of concurrent speech on hemispheric lateralization of face recognition. *Developmental Neuropsychology, 16*, 253–271.
- Leng, X., & Shaw, G. L. (1991). Towards a neural theory of higher brain function using music as a window. *Concepts in Neuroscience, 2*, 220–258.
- Liederman, J. (1986). Determinants of the enhancement of the right visual field advantage by bilateral vs. unilateral stimuli. *Cortex, 22*, 553–565.
- McGrann, J. V., Shaw, G. L., Silverman, D. J., & Pearson, J. C. (1991). Higher temperature phases of a structured neuronal model of cortex. *Physical Review, A 43*, 5678-5682.

- Mesulam, M. M. (1981). A cortical network for directed attention and unilateral neglect. *Annals of Neurology*, *10*, 309–325.
- Mildner, V. (2002). Languages in space. *Brain and Cognition*, *48*, 463–469.
- Mountcastle, V. B. (1978). An organization principle of cerebral function: The unit module and the distributed system. In G. M. Edelman & V. B. Mountcastle (Eds.), *The mindful brain* (pp. 1–50). Cambridge, MA: MIT.
- Neumann, O., & Klotz, W. (1994). Motor responses to non-reportable, masked stimuli: Where is the limit of direct parameter specification?. In C. Umiltà & M. Moskovitch: *Attention and Performance*, XV (pp. 123-150). Cambridge, MA: MIT Press.
- Newman, J., Rosenbach, J. H., Burns, K. L., Latimer, B. C., Matocha, H. R., & Vogt, E. E. (1995). An experimental test of ‘the Mozart effect’: Does listening to his music improve spatial ability? *Perceptual and Motor Skills*, *81*, 1379–1387.
- Oberman, L. M., Pineda, J. A., & Ramachandran, V. S. (2007). The human mirror neuron system: A link between action observation and social skills. *Social Cognitive and Affective Neuroscience*, *2*, 62-66.
- Rauscher, F. H., & Shaw, G. L. (1998). Key components of the Mozart effect. *Perceptual and Motor Skills*, *86*, 835–841.
- Rauscher, F. H., Robinson, K. D., & Jens, J. J. (1998). Improved maze learning through early music exposure in rats. *Neurological Research*, *20*, 427–432.
- Rauscher, F. H., Shaw, G. L., & Ky, K. N. (1993). Music and spatial task performance. *Nature*, *365*, 611.
- Rauscher, F. H., Shaw, G. L., & Ky, K. N. (1995). Listening to Mozart improves spatial-temporal reasoning: Towards a neurophysiological basis. *Neuroscience Letters*, *6*, 44–47.

- Reuter-Lorenz, P. A., Kinsbourne, M., & Moscovitch, M. (1990). Hemispheric control of spatial attention. *Brain and Cognition*, *12*, 240–266.
- Rideout, B. E., Dougherty, S., & Wernert, L. (1998). Effect of music on spatial performance: A test of generality. *Perceptual and Motor Skills*, *86*, 512–514.
- Shaw, G. L., Silverman, D. J., & Pearson, J. C. (1985). Model of cortical organization embodying a basis for a theory of information processing and memory recall. *Proceedings of the National Academy of Sciences, USA*, *82*, 2364-2368.
- Shaw, G. L., Silverman, D. J., & Pearson, J. C. (1988). Trion model of cortical organization and the search for the code of shortterm memory and information processing. In: *Systems with learning and memory abilities* (Levy J., Delacour J. C. S., eds), pp 411-435. New York. Elsevier.
- Silverman, D. J., Shaw, G. L., & Pearson, J. C. (1986). Associative recall properties of the trion model of cortical organization. *Biological Cybernetics*, *53*, 259-271.
- Steele, K. M., Ball, T. N., & Runk, R. (1997). Listening to Mozart does not enhance backwards digit span performance. *Perceptual and Motor Skills*, *84*, 1179–1184.
- Sterr, A. (2006). Preparing not to move: does no-response priming affect advance movement preparation processes in a response priming task?. *Biological Psychology*, *72*, 154-159.
- Stough, C., Kerkin, B., Bates, T., & Mangan, G. (1994). Music and spatial IQ. *Personality and Individual Differences*, *17*, 695.
- Vogt, S., Taylor, P., & Hopkins, B. (2003). Visuomotor priming by pictures of hands: perspective matters. *Neuropsychologia*, *41*, 941-951.

Vorberg, D., Mattler, U., Heinecke, A., Schmidt, T., & Schwarzbach, J. (2003). Different time courses for visual perception and action priming. *Proceedings of the National Academy of Sciences of the USA*, 100, 6275-6280.

## CHAPTER 3

### A First EEG Study

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**Preliminary Note.** Chapter 3 consists of a partial reprint of the following published article, in which the dissertation author was first author: Giromini, L., Porcelli, P., Viglione, D., Parolin, L., & Pineda, J. (2010). The feeling of movement: EEG evidence for mirroring activity during the observations of static, ambiguous stimuli in the Rorschach cards. *Biological Psychology*, 85, 233-241. This article is Copyright © 2010, Elsevier. Reprinted with permission of the publisher and of the other authors. This article is also the recipient of the 2012 Mary S. Cerney Award, given by the Society for Personality Assessment (SPA) for Outstanding Student Paper on Personality Assessment.

#### *Introduction*

An intriguing issue related to mirror neuron system (MNS) activity is the role played by the nature of the perceptual stimuli. The visual feature that activates mirror neurons is the observation of a significant interaction between the agent of the action (e.g., seeing a hand grasping) and the object being the target of it (e.g., a tea cup). Mirror neurons typically do not respond to the observation either of a hand merely miming an action or an object alone, even when the object is of interest (e.g., food for a monkey). In other words, mirror neurons are part of a neural matching system that allows the observer, during action observation, to place her or himself in the same “internal” situation as when actively executing the same action. An important



experiment showed that the MNS in monkeys responds when the final part of an action, most crucial in triggering the response in full vision, was hidden to the observer, i.e., when the intention of the hand gesture could only be inferred (Umiltà et al., 2001). Similar results were found when the actual stimuli were not moving but rather static images from which dynamic information were extracted (implied motion). For example, the medial temporal/medial superior temporal cortex (MT/MST complex) is thought to activate during the visual experience of real (as in movies) or illusory motion, namely when the observer can infer the position of an object in a subsequent moment in time without seeing the actual movement, such as seeing two photographs of an athlete before and after, for example, heaving the shot put (Kourtzi & Kanwisher, 2000). Similarly, a TMS study indicated that the MNS is responsive when dynamic information about body actions is inferred from static pictures of body postures (photographs of pincer grips) (Urgesi, Moro, Candidi, & Aglioti, 2006). Accordingly, the MNS would be expected to respond when actions are mostly generated “internally”, within the individual’s experience (feeling of motion), and triggered by minimal indirect cues placed “externally”, in the actual static picture itself. This, along with the theoretical considerations discussed in chapter 1, allowed us to hypothesize that the production of M responses to the ambiguous Rorschach stimuli would be associated with MNS activity.

In chapter 2 a first pilot study approaching the question in an indirect way has been discussed; in this chapter a first study conducted with the electroencephalography (EEG) technique is presented.

**MNS and EEG.** Previous studies (Cochin et al., 1998; Oberman et al., 2005, 2007a,b; Pineda et al., 2000) have linked activity in the MNS with activity in the EEG mu frequency band recorded over sensorimotor

cortex. At rest, these sensorimotor neurons spontaneously fire in synchrony (Gastaut, 1952), leading to large amplitude EEG oscillations in the 8–13 Hz ( $\mu$ ) frequency band. When subjects perform an action, these neurons fire asynchronously, reflecting greater levels of active processing during motor movement and observation and thereby decreasing the power of the  $\mu$ -band EEG oscillations (Pfurtscheller et al., 1997). Over the past 50 years there have been several theories relevant to the function of the  $\mu$  rhythm (for a review, see Pineda, 2005). Most recently, results of several studies have uncovered various properties of  $\mu$  suppression that directly link it to the frontal mirror neuron system.

First,  $\mu$  power recorded from electrodes at scalp locations C3 and C4 is reduced by self-initiated movement and observed movement (Babiloni et al., 1999; Cochin et al., 1998; Gastaut, 1952; Oztop and Arbib, 2002). Importantly, similar to mirror neuron activity, the  $\mu$  wave does not respond to nonbiological directional motion such as bouncing balls (Oberman et al., 2005). Furthermore, analogous to previous fMRI studies of the MNS (Buccino et al., 2001), the presence of a target object increases  $\mu$  wave suppression as compared to pantomimed actions (Muthukumaraswamy & Johnson, 2004). Since the  $\mu$  rhythm is generated by activity in sensorimotor areas (Gastaut, 1952), and mirror neurons are located in premotor cortex, it has been hypothesized that the  $\mu$  rhythm may specifically index downstream modulation of primary sensorimotor processing by mirror neurons activity (Muthukumaraswamy and Johnson, 2004; Pineda, 2005).

**Purpose, Rationale and Hypotheses.** Hypothesizing that the production of M responses to the Rorschach test would be linked to the activity of the MNS, nineteen healthy volunteers observed different sets of Rorschach stimuli during attribution, identification, and observation

of human movements and different scenarios while their EEG were recorded.

If the results confirmed the anticipated link, this would suggest that the standard interpretation of M responses on the Rorschach may have a neurophysiological foundation involving MNS activation.

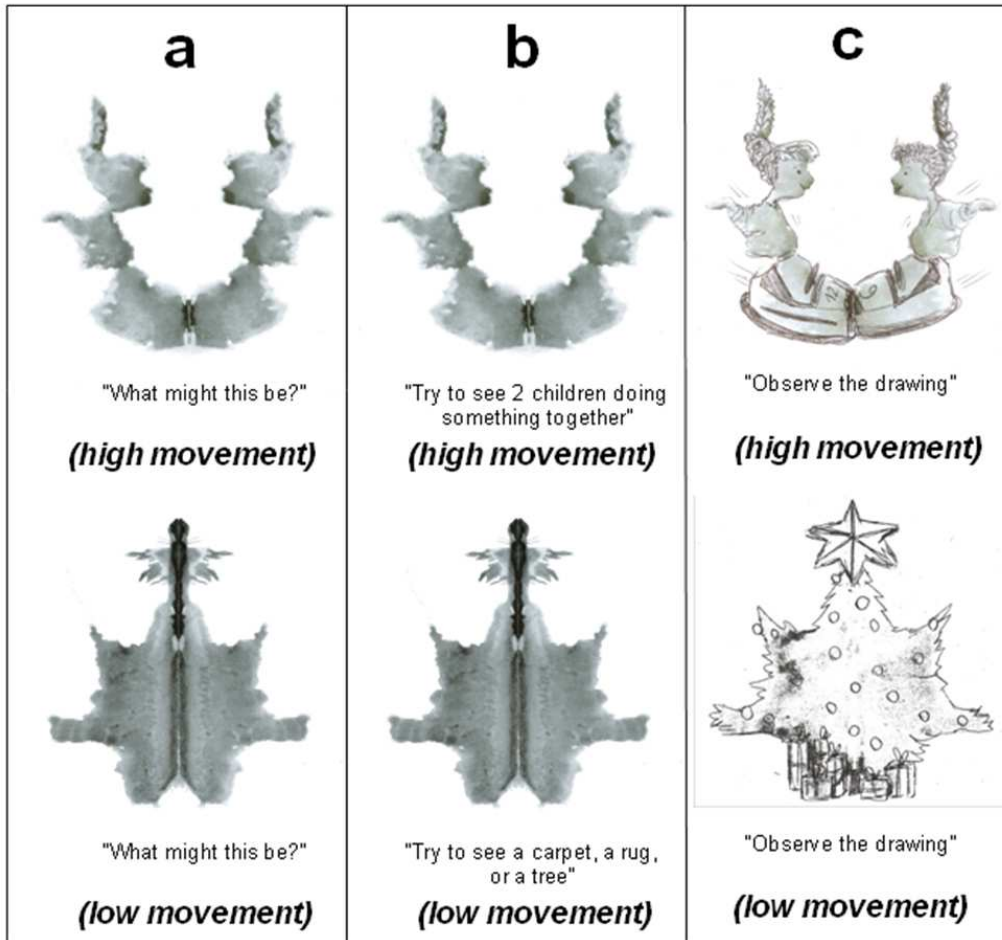
## ***Materials and Methods***

**Participants.** Participants consisted of 20 undergraduate students recruited from the Psychology Department's subject pool at the University of California, San Diego. One subject's data were excluded from analysis due to an excess of head movements and eye blinking (less than 1 s clean data per stimulus was available), resulting in a final sample of 19 subjects (7 male, 12 female) ranging in age from 18 to 27 years ( $M = 20.58$ ,  $SD = 1.98$ ). Participants received class credit for their participation, and all gave written consent. The study was reviewed and approved by the Institutional Review Board of the University of California, San Diego Human Research Protections Program.

**Procedure.** EEG data were collected during baseline and three different experimental, contrast, and control conditions. (*Baseline*) This involved the participant looking at the middle of a white card on a screen. (*A*) *Attribution of human movement* (experimental condition) was evaluated by asking the subjects to look at the Rorschach stimuli with the instruction to think of what they might be (Fig. 3a). This practice is generally consistent with the standard instructions of the Rorschach Comprehensive System (RCS; Exner, 2003), except for the

demands of the computer and EEG recording. Four Rorschach cards were selected for this study, two high M cards (III & VII) with the highest frequency of human movement attribution (M responses) and two low M cards (V & VI) with the lowest frequency of human movement in the reference database (Exner & Erdberg, 2005). Consistent with standard RCS administration, participants were asked to verbalize what they saw after first looking at each of the cards and thinking about their response. (B) *Identification of human movement* (contrast condition) was evaluated by asking subjects to observe the Rorschach stimuli with suggestions verbally provided by the experimenter during the visual exposure to identify a commonly reported movement response (Fig. 3b). The same stimuli as the previous experimental condition A were utilized, but in this condition subjects were guided to identify a commonly reported human movement response (e.g., “two children doing something together”, “two persons arguing with each other”, “two women raising up a heavy basket”) on the two cards with the highest proportion of human movement attribution, and a different commonly reported response (e.g., “a tree”, “a totem pole”, “X-ray of pelvis”) on the two cards with the lowest proportion of human movement attribution. Following the observation period, subjects were asked about the attributions of their responses. We would expect to obtain similar results in both the experimental and contrast conditions. (C) *Observation of human movement* (control condition) was evaluated by asking subjects to observe non-ambiguous hand-made drawings specifically created to resemble the Rorschach inkblots shown earlier (Fig. 3c). Two of the drawings represented a commonly reported human movement response to the related inkblot (such as “two children doing something together”) while the other two represented a different commonly reported response (such as “a tree”).

**Fig. 3. Examples of Stimuli and Instructions.**

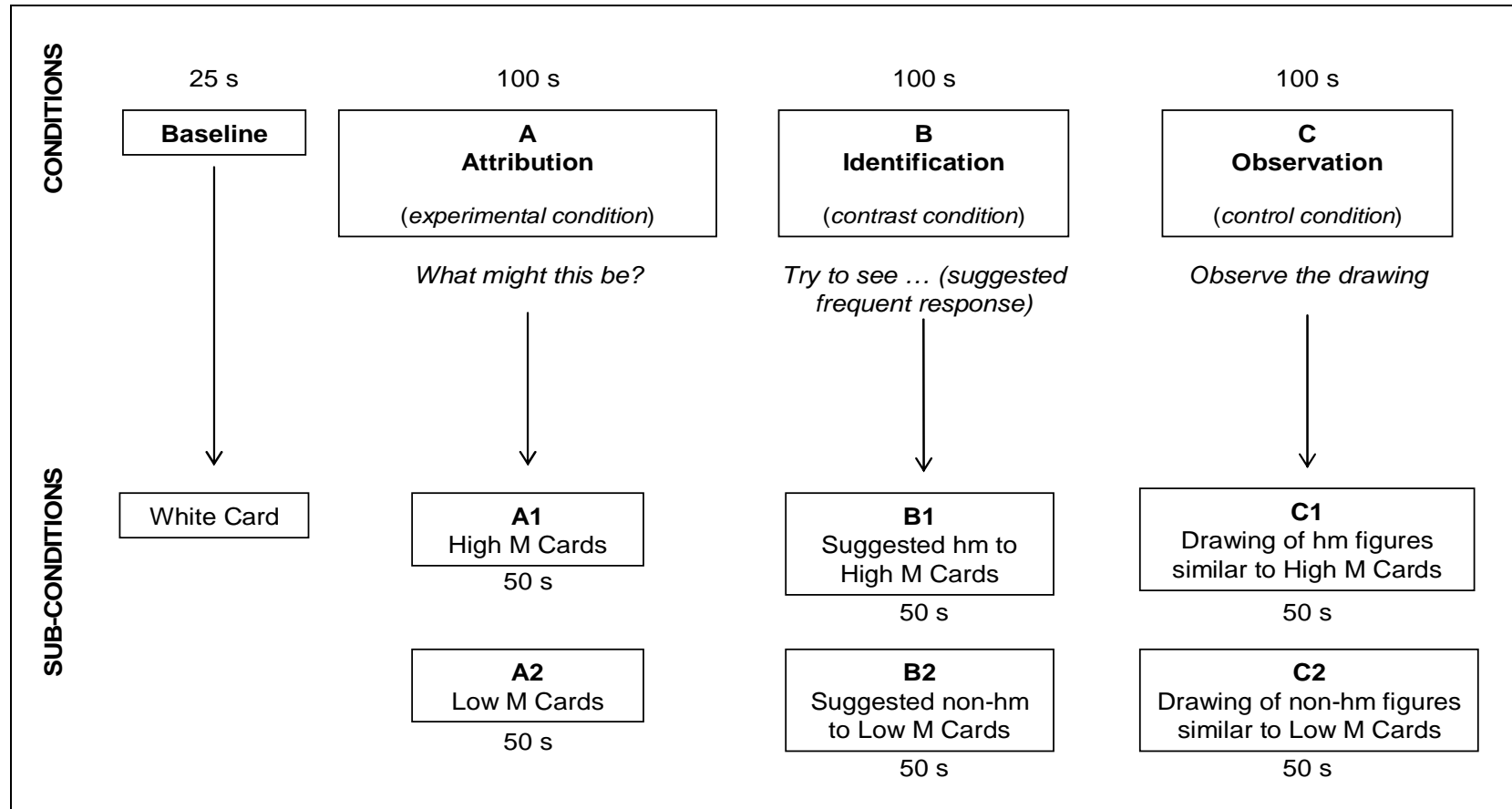


Examples of stimuli and instructions. (a) *Experimental condition*. Stimuli with high proportion of human movement attribution (top) and low proportion of human movement attribution (bottom): subjects were asked to think of what they might be. (b) *Contrast condition*. Same stimuli used in condition "a": subjects were guided to identify either a commonly reported human movement response (top) or a different commonly reported response (bottom). (c) *Control condition*. Drawings resembling the Rorschach stimuli: subjects were asked to observe drawings representing either human movements (top) or absence of movement (bottom). Example stimuli reported in sections (a) and (b) are taken from: Hermann Rorschach, Rorschach-Test, Psychodiagnostic Plates. Copyright by Verlag Hans Huber, Hogrefe AG, Bern, Switzerland. 1921, 1948, 1994, 2009. Reprinted by kind permission of the publisher.

In summary, three main conditions (attribution-A, identification-B, and observation-C), subdivided into six sub-conditions according to the presence or absence of human movement: attribution (*A1*), identification (*B1*), and observation (*C1*) of human movements, and attribution (*A2*), identification (*B2*), and observation (*C2*) of scenarios without human movements. Condition *A*, differed from the other two in that it required the respondent to spontaneously attribute a movement in the card for the corresponding EEG data to be analyzed in the movement condition (*A1*), and to not attribute a movement for the corresponding EEG data to be analyzed in the non-movement condition (*A2*). Therefore, in order to obtain enough clean EEG data, only the experimental *A* condition was presented twice, instructing the subjects to think of a different response each time a stimulus was repeated.

All stimuli were shown on a screen situated at a distance of 96 cm, at a size of 17 cm x 24 cm, like the original Rorschach cards. For the experimental *A* and the contrast *B* conditions, subjects were instructed to continue focusing on their response for the entire period of EEG recording. The baseline condition was presented at the beginning and among the three other conditions, the experimental *A* condition was presented first to insure that the spontaneous responses were not influenced by any form of priming; contrast *B* condition was presented second so as not to allow the drawings to facilitate identification of suggested responses; finally, control *C* condition was presented last. The presentation order of the stimuli within each condition (i.e., stimuli with and without human movement) was randomized (Fig.4).

**Fig. 4. Layout of the study design.**



In the upper half, the sequence of conditions A, B, and C lasting 100 s, after baseline of 25 s. Condition A was presented twice. Specific instructions related are displayed under each condition. In the lower half, the sequence of sub-conditions A1 to C2, lasting each 50 s. Sub-conditions were presented in randomized order. Note: hm = human movement; non-hm = response without human movement; M = Rorschach code for human movement responses.

**EEG data acquisition and analysis.** Disk electrodes were applied to the face above and below the left eye to monitor the electrooculogram (EOG) and behind each ear (mastoids) for use as reference electrodes. Data were collected from 13 electrodes embedded in a cap, at the following scalp positions: F3, Fz, F4, C3, Cz, C4, P3, Pz, P4, T5, T6, O1, and O2, using the international 10–20 method of electrode placement. Following placement of the cap, electrolytic gel was applied at each electrode site and the skin surface was lightly abraded to reduce the impedance of the electrode-skin contact. The impedances on all electrodes were measured and confirmed to be less than 5 k $\Omega$  both before and after testing. Once the electrodes were in place, subjects were seated inside an acoustically and electromagnetically shielded testing chamber. EEG was recorded and analyzed using a Neuroscan Synamps system (band pass 0.1–30 Hz). Data were collected for approximately 100 s per condition – around 50 s per each of the 6 sub-conditions *A1*, *B1*, *C1*, *A2*, *B2*, and *C2* – at a sampling rate of 500 Hz. Given that the baseline task consisted of looking at the middle of a white card, only 25 s of data were recorded during this condition in order to avoid distraction or less engagement with the task because of increasing boredom. Eye blinks as well as eye and head movements were manually identified in the EOG recording, and artifacts during these intervals were removed prior to analysis using traditional methods (Goldensohn, Legatt, Koszer, & Wolf, 1999). For each cleaned segment the integrated power in the 8–13 Hz range was computed using a Fast Fourier Transform. Data were segmented into epochs of 1 s beginning at the start of the segment. Fast Fourier transforms were performed on the epoched data (256 points). A cosine window was used to control for artifacts resulting from data splicing. Data were only analyzed if there were sufficient clean data, i.e., cards with less than 5 valid epochs were removed, and the



different conditions (composed of the combined valid cards) were only analyzed if a minimum of 20 seconds were available.

Mu suppression over sensorimotor cortex (scalp locations C3, Cz and C4) was calculated in all conditions as the ratio of the power during the sub-conditions relative to the power during the baseline condition. As a common procedure for this type of study (Altschuler et al., 2000; Bernier, Dawson, Webb, & Murias, 2007; Martineau, Cochin, Magne, & Barthelemy, 2008; Oberman et al., 2005; Oberman, McCleery et al., 2007; Oberman, Pineda, & Ramachandran, 2007; Pineda & Hecht, 2009; Ulloa & Pineda, 2007), a ratio was used to control for variability in absolute mu power as a result of individual differences such as scalp thickness, electrode placement, and impedance, as opposed to differences in brain activity. Since ratio data are inherently non-normal, as a result of lower bounding, a log transform was used for analysis. A log ratio of less than zero indicates suppression, whereas a value of zero indicates no suppression and a value greater than zero indicates enhancement. Given that one of the subjects had less than 5 s of clean EEG data at the baseline, his data were excluded from the following analysis.

After combining the different stimuli used for the same sub-conditions (i.e., card III and VII for the high movement sub-conditions, and card V and VI for the low movement sub-conditions), a three-way repeated-measures ANOVA was conducted to compare the mu suppression within-subjects across different tasks (attribution, identification, and observation), scalp locations (C3, Cz, and C4), and movement conditions (high movement and low movement).

## **Results**

**(A) Attribution of human movement.** Subject statements were transcribed *verbatim* and coded according to standard RCS rules. Three of the authors, who are experts well trained in the RCS and have been using the RCS in clinical and research settings for many years (two of them for decades), independently coded each transcription and their agreement about the presence vs. absence of M was 100%. Of the 19 participants, 17 saw at least one M response at the high M frequency cards (median M frequency at these stimuli was 2 in this sub-group). Accordingly, 17 participants were retained in the analysis because only they provided EEG recordings for M responses. All 19 subjects produced at least one non-M response to the low M frequency cards and so they all were retained in the analysis (most of them, 17 subjects, gave only non-M responses for these stimuli).

The mu suppression over sensorimotor cortex (scalp locations C3, Cz and C4) during the first and the second presentation of the same stimuli was not significantly different for any card and any scalp location. Hence, a mean mu suppression for each scalp location was computed for each card. The mean mu suppression of each card was then compared to the mean mu suppression of the other card of the same sub-condition (card III and VII for sub-condition A1, card V and VI for sub-condition A2). Again, no significant differences were found, and a mean mu suppression for each scalp location was computed for each sub-condition.

**(B) Identification of human movement.** One subject's data recorded over scalp location C3 were excluded from the following analysis due to technical problems with the EEG apparatus. Like in the Attribution condition, the mu suppression recorded over sensorimotor

cortex (scalp locations C3, Cz and C4) during Identification condition did not differ from the mu suppression recorded during the observation of the other card of the same sub-condition (card III and VII for sub-condition *B1*, card V and VI for sub-condition *B2*), therefore a mean mu suppression for each scalp location was computed for each sub-condition.

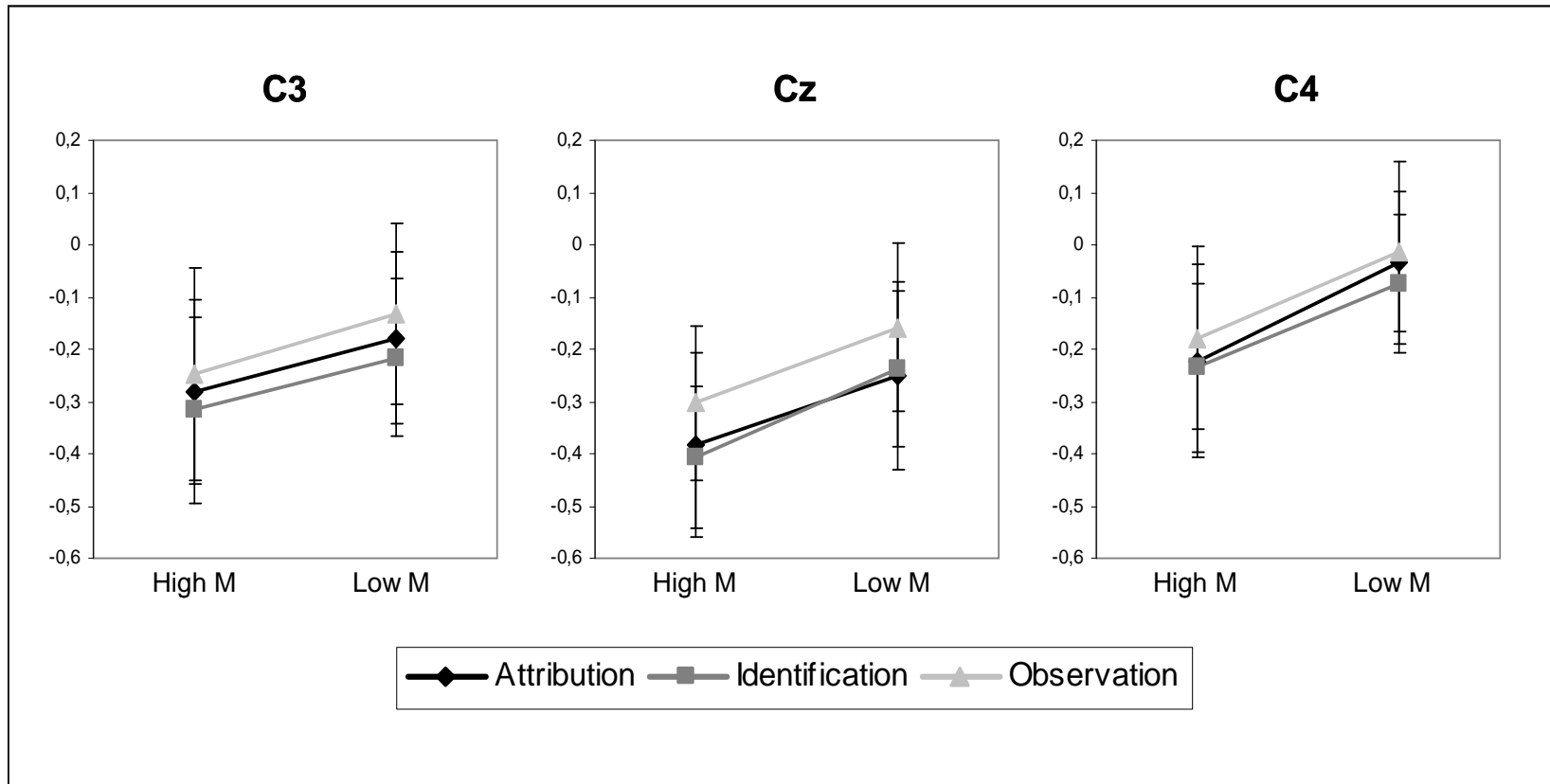
**(C) Observation of human movement.** Since the mu suppression recorded over sensorimotor cortex (scalp locations C3, Cz and C4) during the observation of each card did not differ from the mu suppression recorded during the observation of the other card of the same sub-condition (drawings resembling card III and VII for sub-condition *C1*, drawings resembling card V and VI for sub-condition *C2*), a mean mu suppression for each scalp location was computed for each sub-condition.

**Three-way ANOVA.** A highly significant main effect for movement was found,  $F(1,14) = 12.256$ ,  $p = .004$ ,  $\eta^2 = .06$ , with the high movement conditions presenting a mean mu suppression ( $M = -.29$ ) greater than the low movement conditions ( $M = -.14$ ). Neither the task and scalp location main effects nor any of the various interactions were significant (Fig.5).

**Additional analysis.** In order to rule out the presence of a general global desynchronization effect on other alpha-range rhythms, the same analysis adopted for central sites was implemented for posterior sites (scalp electrodes O1 and O2).

**Attribution of human movement.** Similar to central sites, 8-13 Hz frequency band suppression during first and second presentation of the same stimuli was not significantly different for any card and any scalp

**Fig. 5. Mu Suppression in C3, Cz and C4 for High Movement (High M) and Low Movement (Low M) Sub-Conditions.**



Mu suppression in C3, Cz and C4 for high movement (High M) and low movement (Low M) sub-conditions; different lines refer to different conditions (attribution, identification, and observation). Mu suppression is calculated as the mean log ratio of power in the mu frequency (8–13 Hz) during sub-conditions over the power in the baseline condition. Error bars represent the standard error of the mean. For all values, a mean log ratio less than zero indicates mu suppression.

location, and a mean 8-13 Hz frequency band suppression for each scalp location was computed for each card. The mean 8-13 Hz frequency band suppression of each card was then compared to the mean 8-13 Hz frequency band suppression of the other card of the same sub-condition (card III and VII for sub-condition A1, card V and VI for sub-condition A2). Again similar to central sites, the high movement cards III and VII were not significantly different and a mean 8-13 Hz frequency band suppression for each scalp location was computed for this condition. Unlike the results in central sites, though, card V and VI were significantly different after Bonferroni correction (O1  $t(18) = -2.852$ ,  $p = .021$ , O2  $t(18) = -3.153$ ,  $p = .011$ ), with the low movement card VI showing a greater 8-13 Hz frequency band suppression as compared to the low movement card V both in O1 ( $M = -.24$  vs.  $M = -.05$ ) and O2 ( $M = -.32$  vs.  $M = -.14$ ).

Given that for the identification and the observation tasks 8-13 Hz frequency band suppression of each card was not different from 8-13 Hz frequency band suppression of the other card of the same sub-condition (see below), separate analysis was computed for the attribution task. Because of the difference in the low movement cards, a two-way repeated-measures ANOVA was computed to compare 8-13 Hz frequency band suppression for O1 and O2 in the combined high movement cards (III and VII) to 8-13 Hz frequency band suppression in the individual low movement cards. A significant main effect of stimulus was found,  $F(2,32) = 9.666$ ,  $p = .001$ ,  $\eta^2 = .29$ , with the low movement card V showing less 8-13 Hz frequency band suppression ( $M = -.05$ ) compared both to the low movement card VI ( $M = -.27$ ) and to the combined high movement cards ( $M = -.27$ ). Pair-wise comparisons revealed that both the difference between card V and the combined high movement cards ( $p = .015$ ) and the difference between card V and card VI ( $p = .006$ ) were significant. 8-13 Hz frequency band

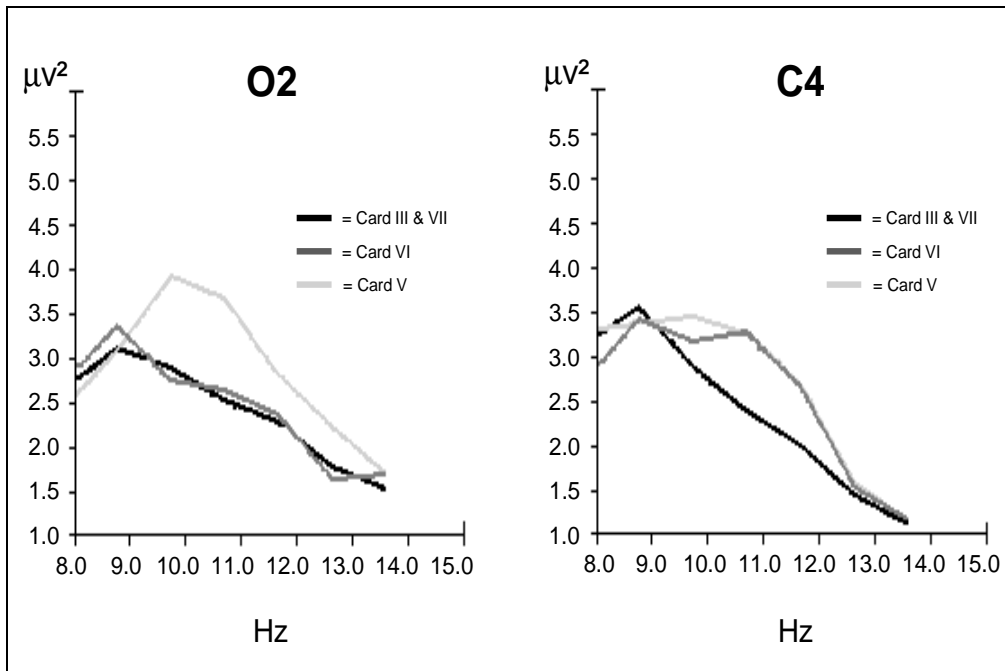
suppression in the combined high movement cards was not significantly different from 8-13 Hz frequency band suppression in the low movement Card VI. A significant main effect of scalp location also occurred,  $F(1,16) = 5.322$ ,  $p = .035$ ,  $\eta^2 = .04$ , with O2 presenting a mean 8-13 Hz frequency band suppression ( $M = -.23$ ) greater than O1 ( $M = -.16$ ).

In Figure 6 frequency spectral graphs for 8-13 Hz frequency band power during card V, card VI, and the combined high movement cards in occipital and central right sites (O2 and C4) are presented.

**Identification and observation of human movement.** For the identification and the observation tasks, 8-13 Hz frequency band suppression during the presentation of the two stimuli of the same sub-condition was not significantly different and a mean 8-13 Hz frequency band suppression for each scalp location was computed for each sub-condition (B1, C1, B2, and C2). A three-way repeated-measures ANOVA was then conducted to compare the 8-13 Hz frequency band suppression within-subjects across different tasks (identification and observation), scalp locations (O1 and O2), and movement conditions (high movement and low movement). Similar to central sites, a significant main effect of movement was found,  $F(1,18) = 12.634$ ,  $p = .002$ ,  $\eta^2 = .20$ , with the high movement conditions presenting a mean 8-13 Hz frequency band suppression ( $M = -.27$ ) greater than the low movement conditions ( $M = -.03$ ). Unlike the results in the central sites, however, a significant main effect of task was found,  $F(1,18) = 5.099$ ,  $p = .037$ ,  $\eta^2 = .05$ , with the identification task presenting a mean 8-13 Hz frequency band suppression ( $M = -.21$ ) greater than the observation task ( $M = -.09$ ). Furthermore, a marginally significant main effect of scalp location also occurred,  $F(1,18) = 3.977$ ,  $p = .062$ ,  $\eta^2 = .02$ , with O2 presenting a mean 8-13 Hz frequency band suppression ( $M = -.19$ )

greater than O1 ( $M = -.12$ ). None of the various interactions were significant.

**Fig. 6. Frequency spectral graphs for 8-13 Hz frequency band power during the attribution task at occipital and central right sites (O2 and C4).**



Data for card V, card VI, and the combined high movement cards (III and VII) are presented. For each electrode, Y axis refers to power, X axis to frequency (8-13 Hz frequency band is presented). Black lines refer to the two combined high movement cards, dark gray lines refer to the low movement card VI and light gray lines to the low movement card V. At the right central site the two high movement cards show greater mu suppression (lower mu power) as compared to both the low movement cards; differently, at the right occipital site the low movement card VI and the high movement cards present similar 8-13 Hz frequency band rhythm.

## ***Discussion***

In this study, properties of the stimuli that would modulate the activity of the MNS were examined, with a specific emphasis on static and ambiguous qualities of the perceptual field that convey a “feeling of movement”. As predicted by our hypothesis, the results showed that greater mu wave suppression occurred at C3, Cz, and C4 sites for all the movement sub-conditions as compared to the non-movement sub-conditions. Given that such a reduction in mu power has been associated with increased MNS activity (Cochin et al., 1998; Oberman et al., 2005; Oberman, McCleery et al., 2007; Oberman, Pineda, & Ramachandran, 2007; Pineda et al., 2000), this finding suggests that this system is activated not only when actions in the static figures are strongly suggested by the features of the stimuli (non-ambiguous drawings closely resembling the Rorschach cards in the control *C1* movement-observation condition), but also by the suggestions verbally provided by the experimenter during the visual exposure to ambiguous stimuli (Rorschach cards used during the contrast *B1* movement-identification condition), as well as when actions are completely determined by subjective internal representation of human movement (Rorschach cards used during the experimental *A1* movement-attribution condition).

To rule out a general global desynchronization explanation for these results, the 8-13 Hz frequency band activity from occipital sites was examined too. If findings at the central sites were only due to a global desynchronization phenomenon, similar activity patterns at both central and occipital sites would be expected.

For the identification and observation tasks such an explanation cannot be completely ruled out. Indeed, similar to central sites, a main effect of movement was found in the occipital sites as well, and in the



same direction. However, other results are inconsistent with a single global alpha-like explanation: Unlike the finding in the central sites, in the occipital sites a significant main effect of task and a marginally significant main effect of scalp location also occurred.

Stronger evidence against the single global alpha-like explanation emerges for the attribution task. Unlike the results in the central sites, 8-13 Hz frequency band suppression to the two low movement cards at occipital sites differed substantially so that they could not be combined. 8-13 Hz frequency band suppression to one of the low movement cards (card VI, sub-condition A2) was identical to the combined high movement cards (card III and VII, sub-condition A1). Accordingly, examination of the frequency spectral graphs confirmed that the 8-13 Hz frequency band power during attributions is consistent with an expected effect (more suppression for both high movement cards as compared to both low movement cards) on central and not occipital sites, especially at the right side. A remaining puzzling observation for the attribution task is the high 8-13 Hz frequency band power found for card V at occipital sites. A possible explanation may be that card V “pulls” for a specific, simple, popular response (i.e., “a bat” or “a butterfly”) more often than do card III, VI and VII (Exner & Erdberg, 2005), and that for this reason the answer to the question “what might this be?” is an easier task to solve for card V than for the other cards. Other explanations may be possible as well. Nonetheless, the different patterns observed in central vs. occipital sites suggest that, at least for the attribution task, the mu suppression in central sites is not just due to a global alpha-like effect, but more likely related to MNS activation.

Thus, even with some limitations, these results suggest for the first time that the self-initiated “feeling of movement” internally perceived and cognitively processed by the subjects and identified by the Rorschach code of M is a powerful stimulus for modulating the MNS

activity that a large body of literature has shown to be triggered by actual perceived action performed by human beings.

Mirror neurons are premotor neurons that fire when the subject performs an action and also when the subject observes another subject performing an action (Buccino et al, 2001; Dapretto et al, 2005; Gallese, 2003; Rizzolatti et al., 2001; Umiltà et al, 2001). So far, research data have shown that the MNS is not, however, a biological mechanism for action recognition, but that some specific clues of the stimulus are required for the activation of this neural system such as a goal, an agent, and a context for the perceived action. The use of the static, ambiguous Rorschach inkblots allows us to clarify the power of a prerequisite that seems necessary for the MNS activation, the identification with the other. The importance of this process is underscored in our experiment by the minimal perceptual clues provided by the stimuli that are, however, presumably sufficient for the firing of the mirror neurons.

Non-human and static pictures have been used in MNS research for ascertaining the role played by the understanding of intentions. Oberman, McCleery et al. (2007) used videos of robot hands engaged in object-directed (picking up a ball) and no-object (opening and closing hand with no object present) actions and human hands moving volitionally (opening and closing the right hand) and nonvolitional (hand being moved by a string) movement. They found that both human and robot movement suppressed the mu wave to relatively the same extent, suggesting that the “humanness” and the volitional qualities of the stimulus are not necessary for the MNS activity. In addition, the observation of static pictures of dynamic action seems to produce effects on movement-related brain areas (Proverbio, Riva, & Zani, 2009) and specifically MNS activation (Rizzolatti & Craighero, 2004). The medial temporal/medial superior temporal cortex (MT/MST

complex) has been shown to activate while observing implied motion, i.e., dynamic information extracted from static images (Kourtzi & Kanwisher, 2000). Inferring motion from still images is likely to imply high-level perceptual inference engaging the mirror neuron network that is highly suitable for matching action observation with action execution. Enticott et al. (2008) showed that the MNS activation is associated with static (still facial photographs) but not dynamic (video clips showing the morphing from a neutral to an emotional facial expression) facial emotion processing. Ebisch et al. (2008) found overlapping activation of a mirroring mechanism for tactile experiences and the sight of touch, regardless of stimuli being animate and inanimate, independent of the intentionality of the observed touch. Our results are consistent with this line of research and confirm that static and non-intentional features of even ambiguously shaped pictures such as the Rorschach test stimuli are sufficient to trigger the MNS firing.

Studies performed so far have used perceptual stimuli in which the action is explicitly (moving objects in video clips) or implicitly (still pictures) placed into the figures. Because of the graphic properties of the Rorschach cards, we showed that the activation of a purely internal representation of the sense of movement is able to activate MNS. It is likely that multimodal proprioceptive channels concur to generate the experience of movement. Indeed, it has been shown that the MNS is not merely related to the visual stimulation but involves other sensory mechanisms and is active for a rich repertoire of body actions. Therefore, the mirror mechanism seems to serve several functions that depend on the part of the motor system that resonates: prefrontal and premotor areas become active in coding actions, subcortical structures as amygdala for emotion-laden stimuli, other circuits that store sensory copies of the action if action understanding is or is not required in the task (Rizzolatti et al., 2001). For instance, audio-visual mirror neurons

in area F5 have been found to discharge when an action can only be heard by sound (Kohler et al., 2002) and both animate and inanimate touch (the sight of objects touching each other) activates inner representations of touch (activation of the MNS responding when the subject is touched and sees someone else being touched) (Keysers et al., 2004). Furthermore, mirror-touch synesthesia, in which the observation of touch on other human beings results in tactile sensation on the subject's own body, was significantly associated with empathy scale scores (Banissy & Ward, 2007). Even pain sensation seems to be involved in embodied simulation as activation in the anterior cingulate cortex and anterior insula has been found when people empathized for another individual in pain (Singer et al., 2004).

A shared process of identification modulated by the network of mirror neurons may therefore underlay the mechanisms of embodied simulation, mentalization, social cognition, and empathy. In an EEG study, subjects watching videos of interactive social actions showed a significant suppression of mu wave compared to watching social non-interactive and non-interactive, non-social actions (Oberman, Pineda, & Ramachandran, 2007) and the magnitude of suppression was similar to that observed in the present study. Because of the lack of clear actions in the Rorschach stimuli set, our findings seem to confirm the hypothesis that the internal sense of identification with a living, moving person is among the most important components of embodied simulation, even when identification relies more on inner representations than external cues. Support for this hypothesis comes from several other data reviewed above that show the MNS activates when watching pain sensations in others (Singer et al., 2004), non-human beings in human-like actions (Oberman, McCleery et al., 2007), actions whose crucial part is hidden and can only be inferred (Umiltà et al., 2001), implied motion in still images (Urgesi et al., 2006), and even

gazing at artwork (Freeberg & Gallese, 2007) and alphabet characters passively observed by right-handers (Longcamp, Anton, Roth, & Velay, 2003) and left-handers (Longcamp, Anton, Roth, & Velay, 2005). Empathic feelings should not be regarded therefore as a mere intuition but as a pre-rationale making sense of behavior, emotions, and cognition of others. As it occurs when individuals watch others engaged in a goal-directed action, an ambiguous figure as a Rorschach card can activate embodied simulation enabling “the observer to use his/her own resources to penetrate the world of the other without the need of explicitly theorizing about it” (Gallese, 2003, p.174). From a broader viewpoint, this view is consistent with the “as-if body loop” referred to by Damasio (1999) who speculated about the ability of the brain in simulation mode to reproduce actual somatic states when emotions are induced not by observing others but also by only feeling them in mind, without an external related stimulus.

From the point of view of the test validity, these findings strongly suggest – for the first time – that the standard interpretation of human movement on the Rorschach may have a neurophysiological foundation involving MNS activation. Indeed, as reviewed in chapter 1, the standard interpretation of the M response as an index of empathy and mentalization relies on the fact that when the respondent attributes a human movement to an ambiguous inkblot he or she matches internally generated representations of human beings and human movements with externally existent ambiguous stimuli, and reproduces within himself or herself the feeling of movement seen in the blot. Accordingly, a precondition for the production of M responses is having the ability to think about human beings (because the representation of human beings and human movements has to be present in the mind of the subject) and identify with them. To say it in other words, the production of M responses is believed to rely on a mechanism of

embodied simulation, and for this reason the M response has traditionally been interpreted as an index of empathy and mentalization. Given that a growing body of research suggests that embodied simulation, empathy and mentalization are linked to the activity of the MNS, the fact that the M response is linked to the activity of the MNS as well provides a strong neurophysiological foundation for its traditional interpretation.

Nonetheless, this study had several limitations. First, as a white card was used as baseline, the possibility that the subjects' spontaneous thinking may activate the MNS at different levels cannot be ruled out. The baseline presentation of the white card for only 25 s was therefore set for minimizing distraction or spontaneous thinking. Second, this limited duration provided a limited amount of clean EEG data and consequently high variability or error in the statistical analysis. Third, the baseline condition showed a lot of alpha activity over occipital sites but relatively less activity over central sites, and this may have biased the mu-suppression-like effect at posterior sites. Fourth, the sample size was small and the presence of artifacts in the EEG signal led to an even smaller sample size. Fifth, in order to not influencing the participants, condition A (spontaneous attribution of human movement) was presented at first and condition C (observation of drawings) at last. Although sub-conditions A1 to C2 were presented at random, lack of randomization of the experimental, contrast, and control conditions may have altered the final results. Finally, although mu wave suppression is considered a valid index of mirror neuron activity (Cochin et al., 1998; Muthukumaraswamy & Johnson, 2004; Oberman, McCleery et al., 2007; Oberman, Pineda, & Ramachandran, 2007; Pineda et al., 2000; Pizzamiglio et al., 2005; Rizzolatti et al., 2001), owing to the low spatial resolution of EEG it is difficult to differentiate between activity selective to the premotor MNS and

activity in other regions that are part of a larger action observation/execution network that may modulate the activity in the premotor MNS (Muthukumaraswamy & Johnson, 2004; Muthukumaraswamy, Johnson, & McNair, 2004). Further investigations with higher-spatial-resolution techniques, such as fMRI and high-resolution EEG, may be able to dissociate between these two sources of activation.

## References

- Altschuler, E. L., Vankov, A., Hubbard, E. M., Roberts, E., Ramachandran, V. S., & Pineda, J. A. (2000, November). Mu wave blocking by observer of movement and its possible use as a tool to study theory of other minds. Poster session presented at the *30th Annual Meeting of the Society for Neuroscience*, New Orleans, LA.
- Babiloni, C., Carducci, F., Cincotti, F., Rossini, P. M., Neuper, C., Pfurtscheller, G., & Babiloni, F. (1999). Human movement-related potentials vs. desynchronization of EEG alpha rhythm: A high-resolution EEG study. *NeuroImage*, *10*, 658-665.
- Banissy, M. J., & Ward, J. (2007). Mirror-touch synesthesia is linked with empathy. *Nature Neuroscience*, *10*, 815-816.
- Bernier, R., Dawson, G., Webb, S., & Murias, M. (2007). EEG mu rhythm and imitation impairments in individuals with autism spectrum disorder. *Brain and Cognition*, *64*(3), 228-237.
- Buccino, G., Binkofski, F., Fink, G. R., Fadiga, L., Fogassi, L., Gallese, V., ... Freund, H. J. (2001). Action observation activates premotor and parietal areas in a somatotopic manner: An fMRI study. *European Journal of Neuroscience*, *13*, 400-404.
- Cochin, S., Barthelemy, B., Lejeune, S., Roux, J., & Martineau, J. (1998). Perception of motion and qEEG activity in human adults. *Electroencephalography and Clinical Neurophysiology*, *108*, 287-295.
- Damasio, A. (1999). *The feeling of what happens: Body and Emotion in the Making of Consciousness*. New York: Harcourt Brace.
- Dapretto, M., Davies, M. S., Pfeifer, J. H., Scott, A. A, Sigman, M., Bookheimer, S. Y., & Iacoboni, M. (2005). Understanding emotions



- in others: Mirror neuron dysfunction in children with autism spectrum disorders. *Nature Neuroscience*, 9, 28-30.
- Ebisch, S. J. H., Perrucci, M. G., Ferretti, A., Del Gratta, C., Romani, G. L., & Gallese, V. (2008). The sense of touch: Embodied simulation in a visuotactile mirroring mechanism for observed animate or inanimate touch. *Journal of Cognitive Neuroscience*, 20, 1611-1623.
- Enticott, P. G., Johnston, P. J., Herring, S. E., Hoy, K. E., & Fitzgerald, P. B. (2008). Mirror neuron activation is associated with facial emotion processing. *Neuropsychologia*, 46, 2851-2854.
- Exner, J. E., Jr (2003). *The Rorschach. A Comprehensive System. Vol. 1. Basic foundations and principles of interpretation (4th edn)*. New York: John Wiley & Sons.
- Exner, J. E., Jr., & Erdberg, P. (2005). *The Rorschach: A Comprehensive System. Vol.2. Advanced interpretation (3rd edn)*. New York: John Wiley & Sons.
- Freeberg, D., & Gallese, V. (2007). Motion, emotion and empathy in esthetic experience. *Trends in Cognitive Science*, 11, 197-203.
- Gallese, V. (2003). The roots of empathy: the shared manifold hypothesis and the neural basis of intersubjectivity. *Psychopathology*, 36, 171-180.
- Gastaut, H. (1952). Etude electrogastrographique de la reactivité des rythmes rolandiques [EEG study of rolandic rhythmes activity]. *Revue Neurologique*, 87, 176-182.
- Goldensohn, E. S., Legatt, A. D., Koszer, S., & Wolf, S. M. (1999). *Goldensohn's EEG Interpretation: Problems of overreading and underreading*. Armonk, NY: Futura Publishing.
- Keysers, C., Wicker, B., Gazzola, V., Anton, J. L., Fogassi, L., & Gallese, V. (2004). A touching sight: SII/PV activation during the observation and experience of touch. *Neuron*, 42, 335-346.

- Kohler, E., Keysers, C., Umiltà, M. A., Fogassi, L., Gallese, V., & Rizzolatti, G. (2002). Hearing sounds, understanding actions: action representation in mirror neurons. *Science*, *297*, 846-848.
- Kourtzi, Z., & Kanwisher, N. (2000). Activation in human MT/MST by static images with implied motion. *Journal of Cognitive Neuroscience*, *12*, 48-55.
- Longcamp, M., Anton, J. L., Roth, M., & Velay, J. L. (2003). Visual presentation of single letters activates a premotor area involved in writing. *NeuroImage*, *19*, 1492–1500.
- Longcamp, M., Anton, J. L., Roth, M., & Velay, J. L. (2005). Premotor activations in response to visually presented single letters depend on the hand used to write: a study in left-handers. *Neuropsychologia*, *43*, 1699-1846.
- Martineau, J., Cochin, S., Magne, R., & Barthelemy, C. (2008). Impaired cortical activation in autistic children: is the mirror neuron system involved? *International Journal of Psychophysiology*, *68*(1), 35-40.
- Muthukumaraswamy, S. D., & Johnson, B. W. (2004). Primary motor cortex activation during action observation revealed by wavelet analysis of the EEG. *Clinical Neurophysiology*, *115*, 1760-1766.
- Muthukumaraswamy, S. D., Johnson, B. W., & McNair, N. A. (2004). Mu rhythm modulation during observation of an object-directed grasp. *Cognitive Brain Research*, *19*, 195-201.
- Oberman, L. M., Hubbard, E. M., McCleery, J. P., Altschuler, E. L., Ramachandran, V. S., & Pineda, J. A. (2005). EEG evidence for mirror neuron dysfunction in autism spectrum disorders. *Cognitive Brain Research*, *24*, 190-198.
- Oberman, L. M., McCleery, J. P., Ramachandran, V. S., & Pineda, J. A. (2007a). EEG evidence for mirror neuron activity during the observation of human and robot actions: Toward an analysis of the

- human qualities of interactive robots. *Neurocomputing*, 70, 2194-2203.
- Oberman, L. M., Pineda, J. A., & Ramachandran, V. S. (2007b). The human mirror neuron system: A link between action observation and social skills. *Social Cognitive and Affective Neuroscience*, 2, 62-66.
- Oztop, E., & Arbib, M. A. (2002). Schema design and implementation of the grasp-related mirror neuron system. *Biological Cybernetics*, 87, 116-140.
- Pfurtscheller, G., Neuper, C., Andrew, C., & Edlinger, G. (1997). Foot and hand area mu rhythms. *International Journal of Psychophysiology*, 26, 121-135.
- Pineda, J. A., & Hecht, E. (2009). Mirroring and mu rhythm involvement in social cognition: are there dissociable subcomponents of theory of mind?. *Biological Psychology*, 80, 306-314.
- Pineda, J. A. (2005). The functional significance of mu rhythms: Translating “seeing” and “hearing” into “doing”. *Brain Research Reviews*, 50, 57-68.
- Pineda, J. A., Allison, B. Z., & Vankov, A. (2000). The effects of self-movement, observation and imagination on mu rhythms and readiness potentials (RP's): Toward a brain-computer interface (BCI). *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 8, 219-222.
- Pizzamiglio, L., Aprile, T., Spitoni, G., Pitzalis, S., Bates, E., D'Amico, S., & Di Russo, F. (2005). Separate neural systems for processing action- or non-action-related sounds. *NeuroImage*, 24, 852-861.
- Proverbio, A. M., Riva, F., & Zani, A. (2009). Observation of static pictures of dynamic actions enhances the activity of movement-related brain areas. *PLoS One*, 4, e5389.

- Rizzolatti, G., & Craighero, L. (2004). The mirror neuron system. *Annual Review of Neuroscience, 27*, 169-192.
- Rizzolatti, G., Fogassi, L., & Gallese, V. (2001). Neurophysiological mechanisms underlying the understanding and imitation of action. *Nature Review Neuroscience, 2*, 661-670.
- Singer, T., Seymour, B., O'Doherty, J., Kaube, H., Dolan, R. J., & Frith, C. D. (2004). Empathy for pain involves the affective but not sensory components of pain. *Science, 303*, 1157-1162.
- Ulloa, E. R., & Pineda, J. A. (2007). Recognition of point-light biological motion: mu rhythms and mirror neuron activity. *Behavioural Brain Research, 183*, 188-194.
- Umiltà, M. A., Kohler, E., Gallese, V., Fogassi, L., Fadiga, L., Keysers, C., & Rizzolatti G. (2001). "I know what you are doing": A neurophysiological study. *Neuron, 32*, 91-101.
- Urgesi, C., Moro, V., Candidi, M., & Aglioti, S. (2006). Mapping implied body actions in the human motor system. *The Journal of Neuroscience, 26*, 7942-7949.

## CHAPTER 4

### A Second EEG Study

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**Preliminary Note.** Chapter 4 consists of a partial reprint of the following published article, in which the dissertation author was second author and co-investigator: Pineda, J., Giromini, L., Porcelli, P., Parolin, L., & Viglione, D. (2011). Mu suppression and human movement responses to the Rorschach test. *NeuroReport*, 22 (5), 223-226. This article is Copyright © 2011, Wolters Kluwer Health | Lippincott Williams & Wilkins. Reprinted with permission of the publisher and of the other authors.

#### *Introduction*

Mu suppression and mirror neuron system (MNS) activity have typically been investigated during the execution or the observation of actual or filmed movements. In contrast, our earlier study (described in chapter 3) investigated whether mu suppression occurs in the same way when actions are generated 'internally', as part of the individual's inner experience or 'feeling of movement'. As hypothesized, our data showed that mu suppression accompanied such 'feeling of movement' on the Rorschach test.

Nevertheless, several factors limited the implications of those findings. First, only four inkblot stimuli were used, two Rorschach cards with the highest frequency and two with the lowest frequency of human movement (M) responses. Accordingly, the two conditions (M vs. non-M) were visually different, a possible confound, and this visual

difference may have caused the small significant differences found at occipital sites. Second, the baseline condition (looking at a white card on a computer screen) was recorded during a short, 25-s period without assessing the individual's level of attention to the task. Conceivably, distraction, free thinking, and boredom might have affected attentional levels later in the exposure period. Finally, with only four Rorschach stimuli and small sample size, limited amount of data were analyzed.

The primary goal of this study was to examine the relationship between M responses to Rorschach inkblots and the suppression of EEG mu rhythms. Thus, the intent was to provide a more definitive test of the hypothesis than our earlier study in a more ecologically valid way, with more data, while addressing limitations. Accordingly, we used all the 10 cards of the standard Rorschach test, a more appropriate control for baseline attention, and longer data collection periods.

## ***Materials and Methods***

**Participants.** Participants were 24 undergraduate students (17 female) recruited from the Psychology Department's subject pool at the University of California, San Diego (UCSD). Age ranged from 18 to 25 years, with a mean of 20.4 years ( $SD = 1.9$ ). All participants received class credit and gave written consent. The study was approved by the Institutional Review Board at UCSD.

**Procedure.** Stimuli were shown on a screen situated at a distance of 96 cm, at a size of 17 x 24 cm, similar to the original Rorschach

cards. During exposure, participants were instructed not to talk or move (visual inspection confirmed that participants did not move). The baseline stimulus was 90 s of visual white noise. To ensure that participants attended to the screen, they were asked to engage in a continuous performance task. Randomly, the screen turned red five times and blue four times, each color change lasting for 1 s, during the 90 s baseline period. Participants were asked to count the number of times the screen turned red. Their counts at the end of the baseline session were 100% accurate. In the experimental condition, participants viewed all 10 Rorschach cards, one at a time, with the instruction to think of what they might be, consistent with the standard instructions of the Rorschach Comprehensive System (RCS) (Exner, 2003). Each Rorschach card was presented on the computer screen for 30 s. Participants were instructed to focus on their response for the entire period. After 30 s, the image disappeared from the screen and participants were asked to verbalize their response to the stimulus. This entire sequence was repeated once with only one change. Participants were instructed to think, for each card, of a different response from what they had articulated earlier. This second sequence allowed us to aggregate more data: 20 responses and 600 s of EEG data (30 s per response).

**Electroencephalography data acquisition and analysis.** Data were collected from 13 electrodes embedded in a cap, at scalp positions: F3, Fz, F4, C3, Cz, C4, P3, Pz, P4, T5, T6, O1, and O2, using the international 10–20 method of electrode placement. EEG was recorded and analyzed using a Neuroscan Synamps system (Neuroscan Inc., North Carolina, USA) (band pass 0.1–30 Hz). Data were collected for 690 s (90 s for the baseline and 600 s for the experimental condition) at a sampling rate of 500 Hz. After removing

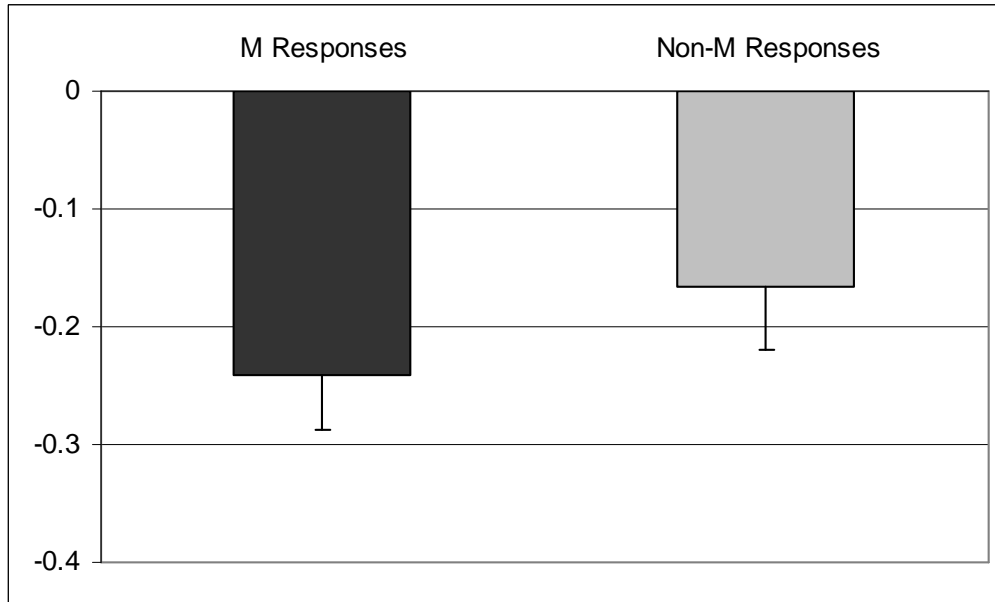
artifacts for each cleaned segment, the integrated power in the 8–13 Hz range was computed using a Fast Fourier Transform. Data were segmented into epochs of 1 s beginning at the start of the segment and Fast Fourier Transforms were performed on the epoched data (256 points). Mu suppression over sensorimotor cortex was calculated as the ratio of the power during the experimental condition divided by the power during the baseline condition (Ulloa & Pineda, 2007; Pineda & Hecht; 2009). A log ratio transform controlled for variability in absolute mu power and the inherent non-normal distribution of ratio data. A mu suppression index at each scalp location was computed for each inkblot, corresponding to the log ratio of mu power during the observation of the inkblot over mu power during the baseline. A log ratio of less than zero indicates suppression. A two-way repeated-measures analysis of variance compared the mean mu suppression using response (M and non-M) and scalp location (C3, Cz, and C4) as within subject factors.

## ***Results***

Participant responses were transcribed verbatim and coded according to RCS standards. Two experts independently coded each transcription and reached 100% agreement about the presence versus absence of M responses. The mean of M responses was 4.3 (SD = 2.2; range = 1–9). A highly significant main effect of response was obtained [ $F(1,23) = 18.755$ ,  $p < 0.001$ ,  $\eta^2 = 0.17$ ], with M responses eliciting a mean mu suppression ( $M = -0.24$ ) greater than the non-M responses ( $M = -0.17$ ) (Fig. 7). Scalp location and interaction (scalp location  $\times$  response) were not significant.



**Fig. 7. Mu Suppression at Central Sites During M and Non-M Responses.**



Mean mu suppression at central sites during the identification of human M responses (black bars) and other non-M responses (gray bars) to the Rorschach cards. Mu suppression is calculated as the mean log ratio of power in the  $\mu$  frequency (8–13 Hz) during experimental conditions over the power in the baseline condition. Error bars represent the standard error of the mean.

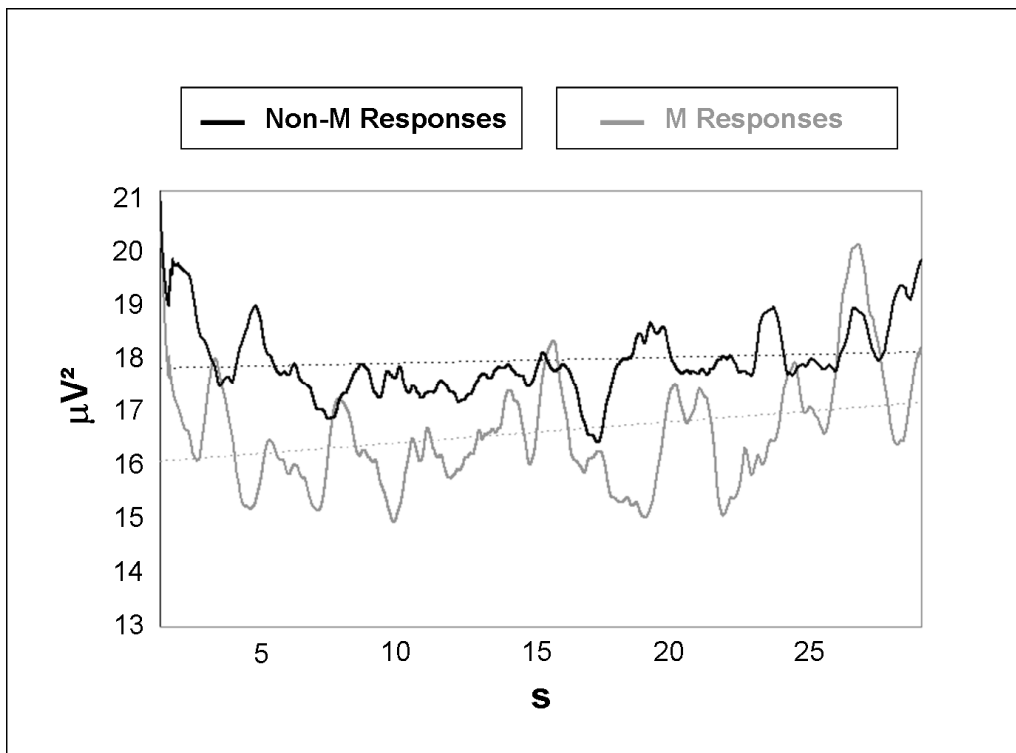
To rule out general global desynchronization effects on other  $\alpha$ -like rhythms (e.g., occipital  $\alpha$ ), the central site analysis strategy was applied to the posterior sites (scalp electrodes O1 and O2). Neither response [F(1,23) = 0.557,  $p=0.46$ ,  $\eta^2 = 0.01$ ], scalp location [F(1,23) = 1.074,  $p=0.311$ ,  $\eta^2 = 0.02$ ], nor the interaction were significant [F(1,23) = 0.476,  $p=0.50$ ,  $\eta^2 < 0.005$ ]. Thus, 8–13Hz frequency band suppression was specific to central and not occipital sites for M compared with non-M responses.

**Additional analysis.** To determine whether the observed movement-related suppression was evoked by the initial subjective response processes underlying M and non-M responses, event related desynchronization (ERD) analyses were undertaken.

For each trial, the first 500 ms were used as reference point, and the ongoing mu power computed relative to that baseline. M and non-M responses were then averaged for each participant. Given that no significant effect of scalp location was found, C3, Cz, and C4 were averaged. Finally, averages among all participants were computed. The resulting ERDs were then smoothed using the moving median technique (which is more robust to outliers than the moving mean) on a 500 ms time span basis.

As shown in Fig. 8, the differences in mu power are substantially early on and remain so for the entire exposure time. If mu suppression was evoked by the subsequent focusing on 'selected' responses and not by processes underlying M responses, one should expect the difference between mu power during non-M and M responses to increase with the time. In fact, the Spearman correlation between time (measured by 2ms points) and mu power differences (non-M mu power minus M mu power) is significant in the opposite direction,  $r = -0.19$ ,  $p$  value of less than 0.001. This result suggests that mu suppression tends to be even stronger at the beginning of the exposure time than at the end.

***Fig. 8. Event-Related Desynchronization in the Mu Power for Movement (M) and Nonmovement (Non-M) Responses.***



The black line shows ERD of mu power at central sites (C3, Cz, and C4) during non-M responses; the gray line represents ERD of mu power at central sites (C3, Cz, and C4) during M responses. Linear interpolation lines are presented as well.

## ***Discussion***

This study extends our earlier findings in which a small subset of Rorschach inkblot cards that typically elicit movement responses (M responses) was associated with mu suppression. Using the standard 10 inkblot set, we found that mu suppression at central sites was greater during the observation of static, ambiguous stimuli that evoked human beings in action (M responses) compared with identification of static or nonhuman objects (non-M responses). This 8–13 Hz frequency band suppression was specific to central sites, supporting the hypothesis that internal representation of the ‘feeling of movement’

elicited by these inkblot stimuli may be sufficient to trigger MNS-related activity even when no external explicit cues are present. The conclusions were made more robust by controlling for limitations that characterized the earlier study (e.g., no control for the participants' attention during the short baseline period and the use of a small pool of selected Rorschach stimuli). This study used a larger sample (24 vs. 15 participants) and a much longer baseline period for EEG recording (90 vs. 25 s) than the earlier study. In addition, a continuous performance task minimized baseline attentional variation. More importantly, using 10 rather than four Rorschach cards provided a much longer EEG recording for data acquisition (600 vs. 200 s). Furthermore, the Rorschach administration more closely resembled the real-world application of the test, increasing the ecological validity of our findings. The total number of Rorschach responses ( $R = 20$ ) and  $M$  responses (mean = 4.3, SD = 2.2, range = 1 – 9) in our study are similar to values in the RCS normative database (mean  $R = 23.4$ , SD = 5.7; mean  $M = 4.8$ , SD = 2.2, range = 0–12) (Exner & Erdberg, 2005). Furthermore, more data allowed greater discrimination and presumably helped to eliminate occipital effects. It is possible that the observed effects at occipital sites in our first study were due to the visual differences between the inkblots used for the two conditions ( $M$  and non- $M$ ). With better controls, the effect size in this study was almost three times ( $\eta^2 = 0.17$ ) that of the first study ( $\eta^2 = 0.06$ ) falling in the large range of suggested benchmarks (small=0.01; medium=0.06; large=0.14) (Kittler, Menard & Phillips, 2007).

To determine whether  $\mu$  suppression occurred at the early exposure to the stimuli, during the response process versus later thinking about the previously 'selected' response, ERD analyses were undertaken. Results indicated that  $\mu$  suppression at the beginning occurred at an even greater intensity than at the end.

It has been argued that actions, emotions, and sensations seen in others activate our own internal representations of the body states associated with these social stimuli, as if we were experiencing a similar set of actions, emotions, and sensations, a mechanism referred to as embodied simulation (see chapter 1). The human MNS is thought to be an underlying neurological correlate of these experiences. Accordingly, given the absence of explicit perceptual cues depicted in the Rorschach stimuli, our study supports the idea that the internal sense of identification with a living, moving human being might play a central role in embodied simulation, even when identification relies exclusively on internally generated representations. As reviewed in chapter 1, in the extant literature, human movement responses to the Rorschach have been repeatedly associated with psychological factors that are consistent with the MNS-based mechanisms of social cognition and empathy. Our findings give some further support to this association.

Nonetheless, even if mu suppression is hypothesized to be a valid index of mirror neurons activity (Pineda, 2005), the low spatial resolution of the EEG does not allow differentiation between the premotor MNS and other regions that are part of a larger action observation/execution network (Muthukumaraswamy, Johnson, & McNair, 2004). A study involving a higher spatial-resolution technique such as functional magnetic resonance imaging may be warranted to address this limitation.

## ***Conclusion***

This study found that EEG mu rhythms can be activated by static, ambiguous stimuli such as the Rorschach inkblot cards. This finding is consistent with the embodied simulation hypothesis (Gallese, 2003; see chapter 1) and our earlier results (chapter 3) and supports the hypothesis that strong internal representation of the 'feeling of movement' may be sufficient to trigger MNS-related activity even when minimal external cues are present. Furthermore, this study suggests that M response in the Rorschach test may involve mirroring activity in the brain, thus supporting its traditional interpretation as an index of empathy and social cognition.

## References

- Exner, J. E., Jr (2003). *The Rorschach. A Comprehensive System. Vol. 1. Basic foundations and principles of interpretation (4th edn)*. New York: John Wiley & Sons.
- Exner, J. E., Jr., & Erdberg, P. (2005). *The Rorschach: A Comprehensive System. Vol.2. Advanced interpretation (3rd edn)*. New York: John Wiley & Sons.
- Gallese, V. (2003). The roots of empathy: the shared manifold hypothesis and the neural basis of intersubjectivity. *Psychopathology*, 36, 171-180.
- Kittler, J. E., Menard, W., & Phillips, K. A. (2007). Weight concerns in individuals with body dysmorphic disorder. *Eating Behavior*, 8, 115-120.
- Muthukumaraswamy, S. D., Johnson, B. W., & McNair, N. A. (2004). Mu rhythm modulation during observation of an object-directed grasp. *Cognitive Brain Research*, 19, 195-201.
- Pineda, J. A., & Hecht, E. (2009). Mirroring and mu rhythm involvement in social cognition: are there dissociable subcomponents of theory of mind?. *Biological Psychology*, 80, 306-314.
- Pineda, J. A. (2005). The functional significance of mu rhythms: Translating “seeing” and “hearing” into “doing”. *Brain Research Reviews*, 50, 57-68.
- Ulloa, E. R., & Pineda, J. A. (2007). Recognition of point-light biological motion: mu rhythms and mirror neuron activity. *Behavioural Brain Research*, 183, 188-194.

## CHAPTER 5

### Second EEG Study: Additional Analyses<sup>8</sup>

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In the previous two chapters, it has been argued that the association between human movement responses and mirror neuron system (MNS) activity supports the traditional interpretation of human movement (M) responses, in that the MNS is thought to be a neurological correlate of social cognition and social competence. If that was true one might further hypothesize that:

1. the mu suppression phenomenon only occurs for M responses – which are related to social cognition and social competence – and does not occur for other significant Rorschach responses (e.g., animal or inanimate movement responses) which are not related to social cognition and social competence (Hypothesis 1);

2. M responses expected to be more strictly related to social cognition and social competence (e.g., adequately perceived human beings in movement) are more strongly associated to mu suppression than M responses more related to poor social skills (e.g., distorted perceptions of human beings in movement) (Hypothesis 2).

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<sup>8</sup> Most of this section is made up of materials which appear in Porcelli, P., Giromini, L., Parolin, L., Pineda, J. A., & Viglione, D. J. (in preparation). The mirror neuron system and the determinant of movement in the Rorschach: single or multiple constructs?



To investigate these two hypotheses we re-analyzed the data set discussed in chapter 4 and published in *NeuroReport* (Pineda, Giromini, Porcelli, Parolin & Viglione, 2011).

## ***Materials and Methods***

**Participants.** As described in chapter 4, the sample consisted of 24 undergraduate students (17 women and 7 men) recruited from the Psychology Department's subject pool at the University of California, San Diego (UCSD). Age ranged from 18 to 25 years ( $M = 20.4$ ,  $SD = 1.9$ ). All participants received class credits, and gave written consent. The study was approved by the Institutional Review Board at UCSD and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

**Procedure.** As described in chapter 4, stimuli were shown on a screen situated at a distance of 96 cm, at a size of 17 x 24 cm, similar to the original Rorschach cards. EEG data were collected during a baseline and an experimental condition. During exposure to the stimuli participants were instructed not to talk or move. The baseline condition consisted of watching a visual white noise for 90 s. To ensure that participants attended to the screen, they were asked to engage in a continuous performance task. Randomly, the screen turned red five times and blue four times, each color change lasting for 1 s, during the 90 s baseline period. Participants were asked to count the number of times the screen turned red. All participants performed it with 100% accuracy.

The experimental condition consisted of asking the participants to look at the ten Rorschach stimuli, one at a time in order, with the instruction to think of what they might be, consistently with the standard instructions of the CS (Exner, 2003). Two experimental sessions were included. During the first experimental session, each Rorschach image was presented right side up and remained on the computer screen for 30 s. Participants were instructed to continue focusing on their one response for the entire period of EEG recording. At the end of each 30 s exposure, the image was removed from the screen and participants were then asked to verbalize their response to the stimulus. All Rorschach cards were administered during this first experimental session. At the end of this session, participants were asked to repeat the entire task. All Rorschach cards were presented again in the same standard order, with the participants being instructed to think, for each card, of a different response from what they articulated before. Except for this instruction, the second experimental session was identical to the previous one and was scheduled in order to obtain sufficient amounts of clean EEG data.

At the end of the two experimental sessions, a total of 20 responses and 600 s of EEG data (30 s per response) were collected.

**Electroencephalography data acquisition and analysis.** Data were collected from 13 electrodes embedded in a cap, at the following scalp positions: F3, Fz, F4, C3, Cz, C4, P3, Pz, P4, T5, T6, O1, and O2, using the international 10–20 method of electrode placement. EEG was recorded at a sampling rate of 500 Hz and analyzed using a Neuroscan Synamps system (band pass 0.1–30 Hz). After removing artifacts, the integrated power in the 8–13 Hz range was computed using a Fast Fourier Transform. Mu suppression over sensorimotor cortex (scalp locations C3, Cz and C4) was calculated as the ratio of

the power during the experimental condition relative to the power during the baseline condition (Pineda & Hecht 2009; Ulloa & Pineda, 2007). As a common procedure for this type of study (Altschuler, Vankov, Hubbard, Roberts, Ramachandran, & Pineda, 2000; Bernier, Dawson, Webb, & Murias, 2007; Martineau, Cochin, Magne, & Barthelemy, 2008; Oberman et al., 2005, 2007a,b; Pineda & Hecht, 2009; Ulloa & Pineda, 2007), a ratio was used to control for variability in absolute mu power as a result of individual differences such as scalp thickness, electrode placement, and impedance, as opposed to differences in brain activity. Since ratio data are inherently non-normal, as a result of lower bounding, a log transform was used for analysis. Indeed, a mu suppression index for each scalp location was computed for each card, corresponding to the log ratio of mu power during the observation of the card over the mu power during the baseline. A log ratio of less than zero indicates suppression.

**Hypothesis 1.** According to hypothesis 1, because the MNS is thought to be involved in social cognition, the human movement (M) responses should be the unique Rorschach response specifically associated with mu suppression unlike other types of responses such as non-moving human content (non-M H contents), non-human movement as animal's (FM) or inanimate object's (m), color responses (C), shading-achromatic responses (Y, T, V, C'), and pure form responses (F) (Table 1). Thus, if hypothesis 1 was true, one should expect that mu suppression would be strongly associated only with human movement (Table 1, Category 1), and not associated with non-moving human content (Table 1, Category 2), non-human movement (Table 1, Category 3) or other important Rorschach determinants (Table 1, Category 4).

To test this hypothesis, the association between mu suppression and the selected responses (e.g., non-human movement) was

analyzed by implementing the same procedure that Pineda et al. (2011) adopted to investigate the association between M responses and mu suppression. Thus, the mean mu suppression during the observation of the cards with the selected response was compared to the mean mu suppression during the observation of the cards without that response. For example, to investigate the relationship of non-human movement responses to mu suppression, the mean mu suppression during the observation of the cards that the participants attributed FM or m responses to was compared to the mean mu suppression during the observation of the cards that the participants did not attribute any FM or m responses to. The only one exception regards category 2 of table 1: given that it is likely that M responses occur along with human contents, to avoid confounds this contrast was tested after excluding all M responses from the analysis.

**Hypothesis 2.** It was hypothesized that adequately perceived human beings in movement (i.e., M with Form Quality ordinary; M/FQo), active human movement (Ma), and human movement associated with whole human figures (i.e., M with pure H; M/PureH) would be more strongly associated with mu suppression than distorted or unusual perceptions of human beings in movement (i.e., M with Form Quality minus or unusual; M/FQ-/FQu), passive human movement (Mp), and human movement associated with non whole-human figures as animals (A) or human details (Hd) only or human-like figures or details [(H) and (Hd)] (M/NonPureH). Indeed, M/FQo, Ma, and M/PureH responses are considered to be more adequate or enhanced types of M responses – and thus more desirable – than M/FQ-/FQu, Mp, and M/NonPureH (see Table 2).

To test this hypothesis, mu suppression occurring during M/FQo, Ma, and M/PureH responses was compared, respectively, to that occurring during M/FQ-/FQu, Mp, and M/NonPureH.

**Tab. 1. Codes Included in the Analysis of Hypothesis 1.**

<b>Category &amp; Label</b>	<b>Description</b>	<b>Code</b>
1) Human Movement Responses	Any Human Movement [M]	M
2) Non-Moving Human Content Responses	Whole [H], Partial [Hd], or Human-Like [(H), (Hd)] Figures That Are Seen as Non-Moving	Non-M H Contents
3) Non-Human Movement Responses	Animal Movement Determinant [FM] or Inanimate Movement Determinant [m]	FM/m
	Any Color Determinant [FC, CF, pure C]	C
4) Other Rorschach Determinants	Any Shading Determinant Including Diffuse Shading [FY, YF, Y], Texture [FT, TF, T], Tri-dimensional [FV, VF, V, FD], and Achromatic Color [FC', C'F, C']	Shading
	Responses Based Exclusively on the Shape of the Blot [F]	F

Note: In the Comprehensive System, animals that are seen in non species-specific kind of movement are coded M as for the determinant (implying the use of fantasizing activity) and A as content (e.g., "an ant dancing rock 'n' roll").

**Tab. 2. Codes Included in the Analysis of Hypothesis 2.**

<b>Desirable Type of M</b>		<b>Non Desirable Type of M</b>	
Label & Code	Description	Label & Code	Description
<b>Adequate Perception of Human Movement (M/FQo)</b>	<i>Human Movement [M] Associated to Form Quality Ordinary [FQo]</i>	<b>Distorted or Unusual Perception of Human Movement (M/FQ-/FQu)</b>	<i>Human Movement [M] Associated to Form Quality Minus [FQ-] or Form Quality Unusual [FQu]</i>
<b>Active Human Movement (Ma)</b>	<i>Human Movement [M] Associated to Activity [Ma]</i>	<b>Passive Human Movement (Mp)</b>	<i>Human Movement [M] Associated to Passivity [Mp]</i>
<b>Human Movement Associated with Whole Human Figures (M/PureH)</b>	<i>Human Movement [M] Associated to Whole Human Figure [H]</i>	<b>Human Movement Associated with Non Whole Human Figures (M/NonPureH)</b>	<i>Human Movement [M] Associated to Animals [A], Human Details [Hd], and Human-Like Figures or Details [(H), (Hd)]</i>

## **Results**

Participant statements were transcribed verbatim and coded according to standard Rorschach Comprehensive System rules (CS; Exner, 2003). Before analyzing the data, three of the investigators, who are experts well trained in the CS and have been using the CS in clinical and research settings for many years (two of them for more than 10 years), reached 100% agreement for the presence vs. the absence of human movement included in the data analyses. Furthermore, intra-class correlations (ICC) for all the other determinants (color, shading, achromatic and pure form determinants) and contents of interest (animal, human, and human-like contents) showed good (ICC > .60) to excellent (ICC > .74) agreement.

Participants who did not produce any responses of the type specified in an analysis were excluded. The number of excluded data for that purpose is found in Table 3.

**Hypothesis 1.** For each contrast, a two-way repeated-measures analysis of variance compared the mean  $\mu$  suppression using response type (presence vs. absence) and scalp location (C3, Cz, and C4) as within-subject factors.

The main effect for M response (Table 1, Category 1) was highly significant, with a large effect size<sup>9</sup>. The main effect for human contents in the absence of M responses (Table 1, Category 2) was marginally significant. None of the other main effects – i.e., the main effects for non-human movements (Table 1, Category 3), color responses (Table 1, Category 4, first row), shading or achromatic responses (Table 1, Category 4, second row), and pure form responses (Table 1, Category

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<sup>9</sup> This contrast was initially reported in Pineda et al. (2011).

**Tab. 3. Number of Excluded and Included Subjects for Each Analysis.**

<b><i>Contrasts for Hypothesis 1 (Type of Response)</i></b>	<b><i>Excluded</i></b>	<b><i>Included</i></b>
Presence vs. Absence of Human Movement Responses (M)	0	24
Presence vs. Absence of Non-Moving Human Contents (Non-M H Contents) <sup>(a)</sup>	1	23
Presence vs. Absence of Non-Human Movement Responses (FM/m)	0	24
Presence vs. Absence of Color Responses (C)	2	22
Presence vs. Absence of Shading Responses (Shading)	1	23
Presence vs. Absence of Pure Form Responses (F)	0	24
<b><i>Contrasts for Hypothesis 2 (Type of M)</i></b>		<b><i>Excluded Included</i></b>
Adequately (M/FQo) vs. Distorted-Unusually Perceived Human Movement (M/FQ-/FQu)	13	11
Active (Ma) vs. Passive (Mp) Human Movement	6	18
Human Movement Associated with Whole Human Figures (M/PureH) vs. Human Movement Associated with Non Whole Human Figures (M/NonPureH)	7	17

(a) Given that it is likely that M responses occur along with human contents, to avoid confounds this contrast was tested after excluding all M responses from the analysis.



4, third row) – was significant. Accordingly, our hypothesis that Ms are the unique Rorschach responses specifically associated with mu suppression unlike other types of responses is partially confirmed. Details for these contrasts are found in Table 4, Section A.

None of the scalp location main effects was significant. For non-human movements (Table 1, Category 3) the interaction effect (scalp location x response) was significant,  $F(2, 46) = 3.88$ ,  $p = .028$ , but effect size was very small,  $\eta^2 < .01$ , and marginal means analyses did not reveal any significant differences,  $p \geq .13$ . None of the various other interactions was significant.

**Hypothesis 2.** Similarly to the procedure followed to test hypothesis 1, for each contrast, a two-way repeated-measures analysis of variance compared the mean mu suppression using M type (desirable vs. non desirable) and scalp location (C3, Cz, and C4) as within-subject factors.

The comparison between adequately perceived human movement (M/FQo) and distorted-unusually perceived human movement (M/FQ-/FQu) did not produce significant differences. A significant main effect for response was observed, instead, for the comparison between mu suppression for active (Ma) vs. passive (Mp) human movement. Finally, mu suppression for human movement associated with whole human figures (M/PureH) did not significantly differ from mu suppression for human movement associated with non whole human figures (M/NonPureH). Details for these contrasts are found in Table 4, Section B. None of the various scalp main effects nor interactions was significant.

According to our hypotheses, we expected that M responses more strictly related to social cognition would show greater mu suppression.

**Tab. 4. Main Effect on Mu Suppression for Types of Responses (A) and Types of M Responses (B).**

	<i>Presence of Response</i> ( $\mu$ suppression)		<i>Absence of Response</i> ( $\mu$ suppression)		<i>Main Effect for Response</i> (Pres. Vs. Abs.)			
<b>A – Type of Responses</b>	<i>M</i>	<i>S.E.</i>	<i>M</i>	<i>S.E.</i>	<i>F</i>	<i>df</i>	<i>p</i>	$\eta^2$
Human Movement Responses (M)	-.24	.05	-.17	.05	18.76	1,23	.000	.17
Non-Moving Human Contents (Non-M H Contents) <sup>(a)</sup>	-.19	.06	-.15	.05	4.12	1,22	.055	.06
Non-Human Movement Responses (FM/m)	-.17	.06	-.18	.05	.13	1,23	.718	<.01
Color Responses (C)	-.17	.06	-.16	.05	.01	1,21	.930	<.01
Shading Responses (Shading)	-.16	.06	-.19	.05	2.12	1,22	.160	.03
Pure Form Responses (F)	-.17	.07	-.19	.05	.86	1,23	.362	.01
<b>B – Type of M <sup>(b)</sup></b>	<i>M</i>	<i>S.E.</i>	<i>M</i>	<i>S.E.</i>	<i>F</i>	<i>df</i>	<i>p</i>	$\eta^2$
Adequately (M/FQo) Perceived M	-.20	.06	-.13	.07	1.95	1,10	.193	.08
Active (Ma) M	-.30	.07	-.21	.05	7.27	1,17	.015	.13
M Associated with Whole Human Figures (M/PureH)	-.25	.06	-.28	.05	.30	1,16	.593	.01

(a) Given that it is likely that M responses occur along with human contents, to avoid confounds this contrast was tested after excluding all M responses from the analysis; (b) Only M responses are considered for this analysis; absence of M/FQo, Ma, and M/PureH responses, therefore, indicates – respectively – presence of M/FQ-/FQu, Mp, and M/NonPureH responses.

This hypothesis was confirmed only in part. Among the various specifications of human movement (human movement associated with human vs. non-human contents, active vs. passive movement, and human movement associated with ordinary vs. distorted/unusual form quality), only active movement (Ma) was found to significantly associate with greater mu suppression compared to passive movement (Mp). Nonetheless, it should be pointed out that – although nonsignificantly – also the observed mu suppression for M/FQo was higher than mu suppression for M/FQ-/FQu. Given that the effect size of this main effect was medium,  $\eta^2 = .08$ , and that the sample size of this analysis was small,  $N = 11$ , with a greater sample size such a difference might be significant. Thus, more research is needed to untangle whether – as we hypothesized – adequately perceived human movement (M/FQo) are more associated with mu suppression than distorted-unusually perceived human movement (M/FQ-/FQu).

## ***Discussion***

In our previous studies we argued that the observed association between M responses and MNS activity supports the traditional interpretation of M responses, in that the MNS is thought to be a neurological correlate of social cognition and social competence. In this study we further investigated this link. More in detail, we hypothesized that mu suppression would not occur for other movement (e.g., FM or m) or non-movement (e.g., shading) Rorschach responses that are not interpreted as indices of social cognition and social competence. Also, we hypothesized that M responses expected to be more strictly related to social cognition and social competence (e.g., adequately perceived

human beings in movement) would be more strongly associated to mu suppression than M responses more related to poor social skills (e.g., distorted perceptions of human beings in movement).

Our hypotheses were confirmed only partially. As for the first hypothesis – according to which the mu suppression phenomenon would only occur for M responses – we found that none of the several Rorschach responses taken into account were as strongly associated with mu suppression as was the M response. In particular, while the mu waves were strongly suppressed during the production of M responses (i.e., the effect was highly significant with a large effect size), only a marginally significant mu suppression effect (with medium effect size) was found for non-moving human content responses, and no mu suppression was observed for non-human movement, color, shading or achromatic, and pure form responses. Noteworthy, the only one other than the M response that had an impact – albeit only marginally significant – on the mu rhythm is the non-moving human content response. Indeed, according to Exner (2003) the production of human content responses, per se (regardless of the presence or absence of movement), provides information about interest in people. In fact, using Exner's words, "persons with considerable interest in others, for any of a variety of reasons, typically gives several human content responses" (p. 497). Accordingly, one may conclude that these findings support the existence of a link between the mu suppression phenomenon and the production of Rorschach responses related to social cognition and social competence.

As for the second hypothesis – according to which M responses expected to be more strictly related to social cognition and social competence would be more strongly associated to mu suppression than M responses more related to poor social skills – the results are more controversial.

As expected, active movement (Ma) was found to significantly associate with greater mu suppression as compared to passive movement (Mp). Noteworthy, the raw mean value observed for Ma in our small sample was the highest mu suppression value (i.e., -.30) among all the responses we investigated (see Table 4). This result supports our hypothesis 2. According to Exner (2003), indeed, when the frequency of Mp is greater than Ma, it reflects a passive, and possibly dependent, interpersonal style. In fact, when Mp is significantly greater than Ma, the person is “more likely to take flight into passive forms of fantasy as a defensive maneuver, and [...] less likely to initiate decisions or behaviors if the alternative that others will do so is available” (p. 439). Exner referred to this as the “Snow White Syndrome”, which is characterized by avoidance of responsibility and decision making. Accordingly, being Ma presumably more related to social cognition and social competence than Mp, the high mu suppression value observed for Ma gives some support to our hypothesis 2. Importantly, this finding also suggests that the importance of Ma responses may be underestimated among clinicians. In fact, because Mp is less frequent and reflects a more problematic and less desirable type of response than Ma, more often than not Mp receives greater attention than Ma in the clinical context. Instead, according to our data, the Ma response might also actually reveal important information in terms of social cognition and social competence resources. More research is warranted to provide more foundation for such a consideration.

Another prediction of this study concerned the form quality of the M response. The presence of good quality Ms, indeed, is a positive prognostic indicator and M responses associated with distorted form quality may reflect disturbed thinking (Exner, 2003). Accordingly, we expected higher mu suppression for adequate vs. distorted perceptions

of human beings in movement. Despite our expectations, no differences were found. From this point of view, our hypothesis 2 is not supported. However, as noted earlier, a methodological issue may have affected the results. Indeed, because only few M responses were associated with unusual or distorted form quality, this contrast was tested on only 11 participants. Hence, given that the observed difference – albeit nonsignificant – was in the expected direction (i.e., higher  $\mu$  suppression for adequate vs. unusual or distorted perceptions of M) and showed a medium effect size, one may speculate that with bigger sample sizes this contrast might produce statistically significant differences. Thus, more work is needed to settle the debate.

Finally,  $\mu$  suppression for M associated with whole human figures did not significantly differ from  $\mu$  suppression for M associated with non whole human figures. This finding does not support our hypothesis 2. Indeed, traditionally, M responses associated with whole human figures are considered to be more adequate or enhanced types of M responses than M responses associated with non whole human or human-like figures. In fact, according to Exner (2003) the whole human content is the only content coding category used for responses that include whole real people, while human details, and human-like figures do not refer to real people. Thus, whole human contents tend to be chosen by those whose self-image is based more on identifications with real persons, while non whole human figures are likely to be selected by those whose self-image is based more on imagination or internal representations that coincide less with reality. Put simply, whole human contents reflect more accurate, integrated, and complete view of people than human details, and human-like figures. Although the rationale for interpreting the difference between whole human contents and details or human-like figures is quite sound, it should be

pointed out that most M responses not associated with whole human contents are associated with faces (e.g., Card VII: “faces of children talking to each other”). According to Meyer, Viglione, Mihura, Erard, and Erdberg (2011), indeed, “faces are such a compelling interpersonal stimulus that humans are born with brain structures that respond specifically to them and throughout life facial information is processed differently than other types of visual information. Perhaps because of this evolutionary heritage, in combination with suggestive blot features, there is considerable pull on certain cards to identify faces or heads” (p. 335). Therefore, our comparison between M associated with Pure H vs. M associated with Non Pure H may have been biased by the fact that most Non Pure H contents consist of faces, a peculiar type of response that may actually reveal awareness of, or interest in, other people – i.e., social cognition and social competence.

## ***Conclusion***

By investigating the association between mu suppression and several Rorschach responses, this study extends our earlier findings in which the production of M responses was associated with mirroring activity. Three main conclusions can be drawn from these new findings. First, mu suppression specifically occurred for human movement (i.e., M) responses and did not occur for any Rorschach responses involving movement. This is particularly important given the fact that M responses are traditionally interpreted as indices of social cognition and social competence, differently from non-human movement responses (i.e., FM and m). Thus, the link between M responses, social cognition, and mirroring activity is further supported by this

study. Second, these findings confirm that the production of human content responses may reveal important information about the awareness of, or interest in, other people. From this perspective, in particular, further work on the face content appears warranted. Third, future research should also address the possible usefulness of the Ma variable, as in this study it appeared to be strongly associated with mu suppression.

Unfortunately, however, this study is not free from limitations. First, the ecological validity of these findings is to be determined, in that the Rorschach was administered on the screen of a computer, and the standard instructions of the CS (Exner, 2003) could not be followed in detail. As a consequence, some behaviors could not be observed and coded (e.g., card turns). Second, given that some responses have a very low base rate some of the contrasts relied on limited amount of EEG data analyzed. As a result, the sample size for some of the contrasts was small and it was not possible to further elaborate some aspects, such as the possibility that there is a difference, in terms of mu suppression, between face responses and other non whole human responses. Third, although mu suppression is hypothesized to be a valid index of mirroring activity (Pineda, 2005), the low spatial resolution of the EEG does not allow differentiation between the premotor MNS and other regions that are part of a larger action observation/execution network.

Nonetheless, despite all these limitations, this study provides some additional support for the interpretation of the M response to the Rorschach and offers some precious cues for further explorations.



## References

- Altschuler, E. L., Vankov, A., Hubbard, E. M., Roberts, E., Ramachandran, V. S., & Pineda, J. A. (2000, November). Mu wave blocking by observer of movement and its possible use as a tool to study theory of other minds. Poster session presented at the *30th Annual Meeting of the Society for Neuroscience*, New Orleans, LA.
- Bernier, R., Dawson, G., Webb, S., & Murias, M. (2007). EEG mu rhythm and imitation impairments in individuals with autism spectrum disorder. *Brain and Cognition*, *64*(3), 228-237.
- Exner, J. E., Jr (2003). *The Rorschach. A Comprehensive System. Vol. 1. Basic foundations and principles of interpretation (4th edn)*. New York: John Wiley & Sons.
- Martineau, J., Cochin, S., Magne, R., & Barthelemy, C. (2008). Impaired cortical activation in autistic children: is the mirror neuron system involved? *International Journal of Psychophysiology*, *68*(1), 35-40.
- Meyer, G. J., Viglione, D. J., Mihura, J., Erard, R. E., & Erdberg, P. (2011). *Rorschach Performance Assessment System: Administration, coding, interpretation, and technical manual*. Toledo, OH: Rorschach Performance Assessment System.
- Oberman, L. M., Hubbard, E. M., McCleery, J. P., Altschuler, E. L., Ramachandran, V. S., & Pineda, J. A. (2005). EEG evidence for mirror neuron dysfunction in autism spectrum disorders. *Cognitive Brain Research*, *24*, 190-198.
- Oberman, L. M., McCleery, J. P., Ramachandran, V. S., & Pineda, J. A. (2007a). EEG evidence for mirror neuron activity during the observation of human and robot actions: Toward an analysis of the

- human qualities of interactive robots. *Neurocomputing*, 70, 2194-2203.
- Oberman, L. M., Pineda, J. A., & Ramachandran, V. S. (2007b). The human mirror neuron system: A link between action observation and social skills. *Social Cognitive and Affective Neuroscience*, 2, 62-66.
- Pineda, J. A., & Hecht, E. (2009). Mirroring and mu rhythm involvement in social cognition: are there dissociable subcomponents of theory of mind?. *Biological Psychology*, 80, 306-314.
- Pineda, J. A. (2005). The functional significance of mu rhythms: Translating “seeing” and “hearing” into “doing”. *Brain Research Reviews*, 50, 57-68.
- Pineda, J., Giromini, L., Porcelli, P., Parolin, L., & Viglione, D. (2011). Mu suppression and human movement responses to the Rorschach test. *NeuroReport*, 22 (5), 223-226.
- Ulloa, E. R., & Pineda, J. A. (2007). Recognition of point-light biological motion: mu rhythms and mirror neuron activity. *Behavioural Brain Research*, 183, 188-194.

## CHAPTER 6

### A Functional Magnetic Resonance (fMRI) Study

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**Preliminary Note.** This study aims to further investigate the link between the production of human movement (M) responses and mirror neuron system (MNS) activity, through a functional magnetic resonance imaging (fMRI). Because data collection and data analysis are still in progress, it will be described here only briefly, without entering into detail. ***Acknowledgements for this project are due to the Society for Personality Assessment (SPA) and to the Hubbard Foundation, San Diego California.*** The SPA has funded 500\$ to cover part of the costs (e.g., compensation for participants and payment of travels); the Hubbard Foundation has covered the costs of the scanning sessions.

#### ***Introduction***

The main goal of this study was to examine whether the link between M and MNS was confirmed also by fMRI, with the secondary purpose to explore, in case, to what extent the premotor MNS and other regions that are part of a larger action observation/execution network are involved.

For this purpose, we administered the entire set of Rorschach cards, two times, to a sample of 23 volunteer participants during fMRI. While into the scanner, the participants were asked to think of what each card might be, and after that, in a separate room, they were inquired about their responses. This procedure allowed us to examine brain activations associated with several response processes.

First, we broadly examined brain activations associated with the production of M responses as compared to the resting baseline (a fixation cross). Because the human MNS is mainly constituted by the rostral part of the inferior parietal lobe (IPL), the lower part of the precentral gyrus (ventral premotor cortex; vPMC), the posterior part of the inferior frontal gyrus (IFG; for a review, see Rizzolatti & Craighero, 2004), and possibly the superior temporal sulcus (STS; Jellema et al., 2000; Molenberghs, Brander, Mattingley, & Cunnington, 2010; Perrett et al. 1989, 1990), we expected these areas to be more involved during the production of M responses. In addition, because of the complex cognitive processes underlying each Rorschach response, we also expected higher activity for M responses in several, large, brain regions associated with cognition, particularly in the primary visual cortex.

To better detect the hypothesized involvement of the MNS during the production M responses, a second analysis compared brain activations during M vs. other than M (Non-M) responses. This analysis aimed to more precisely identify those patterns of brain activations that are specific to M responses and do not occur for other Rorschach responses.

Because this study is quite innovative in terms of both research design and type of study, an exploratory approach was adopted and the entire activation map was taken into consideration.

## ***Materials and Methods***

**Participants.** Participants were 23 volunteers (12 men), aged 17 to 28 years ( $M = 21.0$ ,  $SD = 2.4$ ). Ten were Caucasian, nine Asian or Indian, and four Hispanic. Most of them were undergraduate students

recruited from the Psychology Department's subject pool at the University of California, San Diego (UCSD). The remaining were volunteers recruited through flyers posted at the Alliant International University (AIU) in San Diego. All participants were right-handed and had normal or corrected-to-normal vision; none of them had a history of psychiatric or neurological disease.

All UCSD students (N = 20) received class credits and earned 15\$ for participation; the remaining participants, which were recruited through flyers posted at the AIU, did not receive class credits but earned 18\$ for participation. The study was approved by the Institutional Review Board of AIU, and all participants gave written consent for participation.

**Experimental design.** Before the scanning session, participants were told that during fMRI they would look at the ten Rorschach cards, with the instruction to think of what they might be. They were asked to think of just one response during each exposure to one card and to think of a different response each time a same card would appear. Also, they were informed that later, outside the scanner, they would be asked about what they thought, and that speaking or moving was not allowed during scanning.

Each scan session began with a high resolution T1-weighted anatomical scan upon which functional activations would be overlaid. This was followed by a functional scanning session during which each participant was exposed twice to the 10 Rorschach cards, each lasting 10 seconds. Card I was presented first, followed by Card II, and so on, ending the sequence with Card X. Then, the entire sequence was repeated, such that the ten cards were presented one more time, again beginning with Card I and ending with Card X. A 16-second rest period

during which a fixation cross was displayed on the screen was presented before each Rorschach card.

During this session a total of 20 Rorschach responses (i.e., two diverse Rorschach responses per card) were expected to be produced by each participant.

At the end of the functional scanning each participant was immediately conducted in a different room, where the Rorschach cards were shown again on the screen of a computer. For each card, the participant was asked to tell the experimenter what he or she thought the first time and the second time the card was presented while into the scanner. He or she was also asked to report how certain he or she was about the correctness of what he or she was reporting, i.e., for each first and second responses, the participant was asked to tell the experimenter if he or she was sure about what he was recalling. A 10-point scale (10 = “totally sure”) was used for this purpose, and only responses that obtained a score of 10 were analyzed. All responses were recorded, transcribed *verbatim*, clarified and subsequently coded according to Rorschach Comprehensive System (CS; Exner 2003) standards.

**Imaging.** Scanning was performed using a 3T Siemens scanner. Hearing was protected using ear plugs and motion was minimized using soft pads fitted over the ears.

During anatomical scanning, 160 T1-weighted slices covering the whole brain were acquired in descending order, with a repetition time of 8 milliseconds. Field of vision was 240 x 240 x 160, with a voxel size of 1 mm<sup>3</sup>. The first two images were excluded due to T1 equilibrium effects. During functional scanning, 33 T2-weighted slices covering the whole brain were acquired every 2 seconds. Slice thickness was 3 mm, and functional resolution was 3 mm<sup>3</sup>.

For each participant, a total of 260 time points (i.e., 520 seconds) was available for data analysis.

**Data analysis.** The statistical parametric mapping software SPM8 ([www.fil.ion.ucl.ac.uk/spm/](http://www.fil.ion.ucl.ac.uk/spm/); Wellcome Department of Imaging Neuroscience, London, UK), running in MATLAB R2010a (MathWorks, Natick, MA), was used for pre-processing and analysis of the fMRI data.

Anatomical and functional images were centered at the anterior commissure (AC), realigned (no head motion greater than 2 mm was observed), coregistered, and normalized (normalized voxel size was 3 mm<sup>3</sup>) to the Montreal Neurological Institute (MNI) brain (Collins et al., 1994). Spatially normalized functional data were then smoothed with a Gaussian kernel of 8-mm full width at half maximum (FWHM).

First-level (i.e., individual subject) analysis was performed using a general linear model with boxcar design to model blood-oxygenation-level-dependent (BOLD) signal changes. First, BOLD signal changes induced by production of M responses relative to fixation were analyzed. Then, BOLD signal changes induced by production of M responses relative to production of Non-M responses followed. Comparisons were performed using t contrasts in SPM.

Results from the first-level analysis were submitted to a second-level (i.e., group) analysis, in which participants were treated as a random effect, thus allowing inference to the general population (Friston, Holmes, & Worsley, 1999). For each contrast, the contrast images of each subject from the first-level were entered into a one-sample t test to create an SPM{t} statistic image. An exploratory threshold of  $p < 0.001$ , uncorrected, with a minimum cluster size of 5 voxels was used for this analysis.

Brain activation images were produced using xjView ([www.alivelearn.net/xjview](http://www.alivelearn.net/xjview)), a viewing program for SPM.

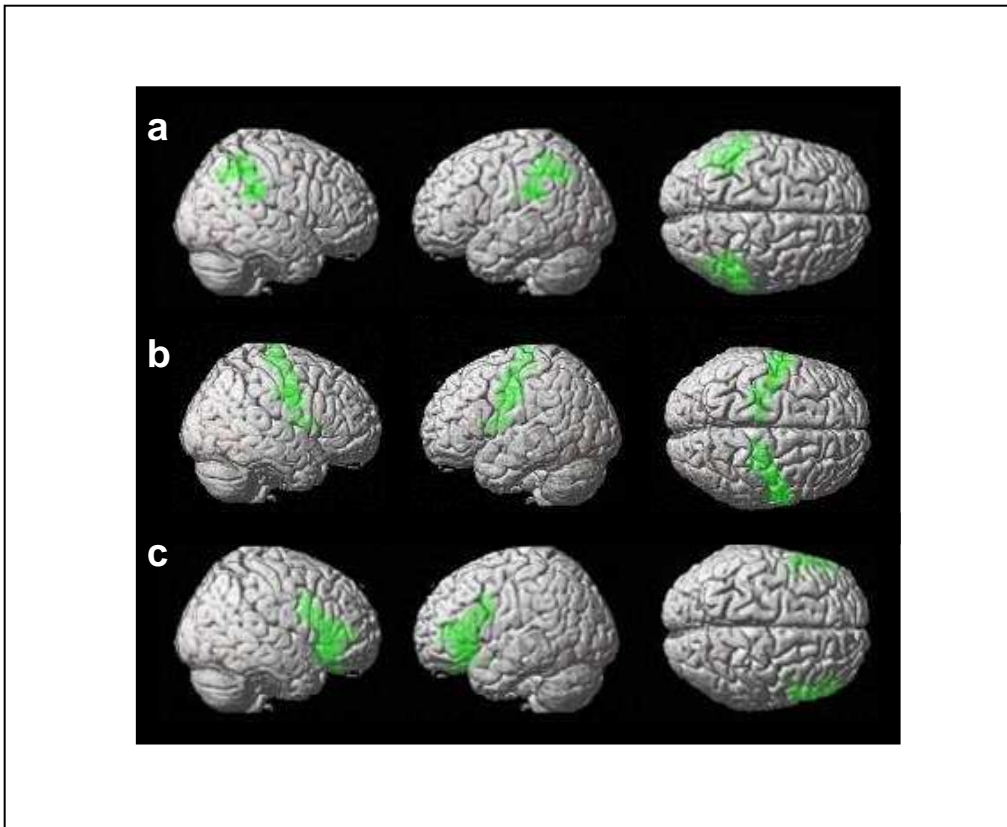
## **Results**

Before analyzing the data, two of the investigators, who are well trained experts in the CS and have been using the CS in clinical and research settings for many years reached 100% agreement for the presence vs. the absence of human movement included in the data analyses. The mean number of M responses produced by the participants was 4.7 ( $SD = 2.4$ ;  $Range = 2$  to 13).

**M responses vs. fixation.** First, blocks associated with M responses were subtracted from those in the fixation blocks to reveal activation areas associated with M responses processing. According to our hypotheses, we expected several areas related to cognition and visual processing to show higher activation during M responses as compared to the baseline. In particular, however, we aimed to investigate the activation of the areas that are commonly associated with the human MNS, such as the IPL, the vPMC and the IFG (Fig. 9).

***Fig. 9. Areas Expected to be Associated with M Responses Production.***

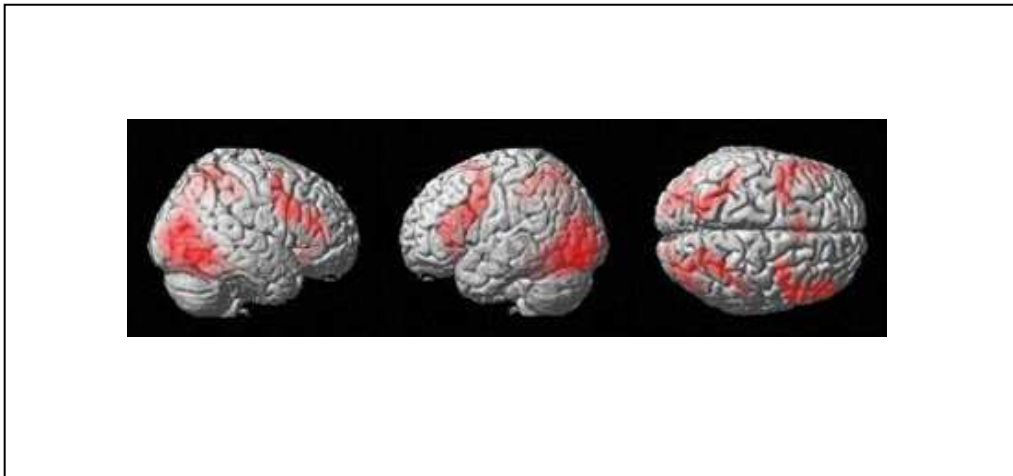




Green areas refer to: (a) Inferior Parietal Lobule (IPL); (b) Precentral Gyrus; (c) Inferior Frontal Gyrus (IFG). The IPL, the lower part of the Precentral Gyrus (i.e., the ventral Premotor Cortex), and the IFG are presumably related to the human MNS.

As expected, maxima of clusters were found to show significantly greater BOLD response in several areas of the brain during M responses, as compared to fixation. In particular, significant activations were shown in the temporal occipital cortex and fusiform gyri, regions associated with visual processing, and in the IFG, one of the most important regions of the human MNS (Rizzolatti & Craighero, 2004). Part of the IPL and of the vPMC showed some activation as well (Figure 10 and Table 5).

**Fig. 10. Observed Activations During M Responses vs. Fixation**



The red areas refer to significant higher activations during M responses as compared to fixation, uncorrected  $p < 0.001$ , with a minimum cluster size of 5 voxels. As expected, these include regions associated with visual processing and some of the areas of the human MNS (primarily the IFG, but also, partially, the IPL and the precentral gyrus).

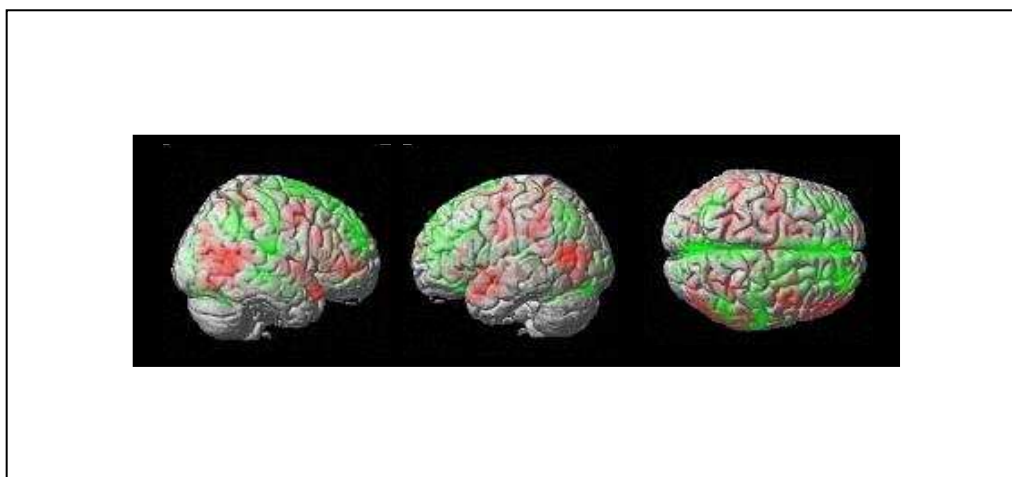
**Tab. 5. Maxima of Clusters Showing Significantly Greater BOLD Response During M Responses as Compared to Fixation.**

<b>Region</b>	<b>x</b>	<b>y</b>	<b>z</b>	<b>T</b>	<b>Z</b>	<b>Voxels</b>	<b>p</b>
Temporal Occipital Fusiform Gyrus Rt	42	-46	-14	15.98	7.40	6870	<0.001
Inferior Frontal Gyrus Rt	48	11	28	10.92	6.33	1448	<0.001
Inferior Frontal Gyrus Lt	-42	5	31	10.05	6.09	1736	<0.001

The exploratory threshold of  $p < 0.001$ , uncorrected, with a minimum cluster size of 5 voxels was used for this analysis. Lt = left; Rt = right. X, y, and z refer to Montreal Neurological Institute (MNI) coordinates.

**M vs. Non-M responses.** To more precisely identify the patterns of brain activations that are specific to M responses and do not occur for other Rorschach responses, blocks associated with M responses were subtracted from those associated with Non-M responses. Contrary to our predictions, no significant activation/deactivation clusters were observed, i.e., no clusters showed neither significantly greater nor smaller BOLD responses during M responses as compared to Non-M responses. A contrast map showing the raw (nonsignificant) differences between the two conditions is presented in Figure 11.

**Fig. 11. Activations During M Responses vs. Non-M Responses**



Red areas refer to nonsignificantly higher activations during M responses as compared to Non-M responses; green areas refer to nonsignificantly higher activations during Non-M responses as compared to M responses. Although an exploratory threshold ( $p < 0.001$ , uncorrected, with a minimum cluster size of 5 voxels) was adopted, no suprathreshold clusters were observed.

A rough visual examination of Figure 11 suggests that part of the middle temporal gyrus (posterior part, bilaterally), part of the left STS (anterior area), part of the left precentral gyrus, and part of the left IPL have been more active during M as compared to Non-M responses. Of

note, most of these areas (especially those showing activity in the left hemisphere, such as the STS, the precentral gyrus, and the IPL) are known to be related to the MNS. These results, however, are not statistically significant.

## ***Discussion***

In this study, aiming to provide further support for the association of M production with MNS activity, 23 volunteer participants were administered the entire set of Rorschach stimuli during fMRI. BOLD signal changes induced by production of M responses relative to fixation and production of Non-M responses were then investigated.

As compared to the baseline, the production of M responses was significantly associated with activations both in regions associated with visual processing and in regions related to the MNS – primarily the IFG, but also the vPMC and the IPL. On the contrary, when compared to the production of Non-M responses, the production of M responses did not show any statistically significant differences in terms of brain activity.

While the results regarding the comparison between M responses and fixation were expected, the lack of differences between M and Non-M responses seems to be in contrast with both our hypotheses and our previous EEG findings (see chapter 3, 4, and 5), according to which the production of M responses was associated with higher mu suppression (EEG index of MNS activity) as compared to the production of Non-M responses. Several possible explanations can be proposed for these findings.

First, it is possible that some technical issues have affected the results. For example, fMRI protocols usually repeat a same stimulus many times to invoke a same process for a sustained period of time, so as to overcome the temporal lack of precision of fMRI. This, of course, was not possible with the Rorschach test, for a number of reasons (e.g., a repeated exposure to a same card would not elicit a same, unique, process; there is much variability in the response process and its temporal length, and so on). Also, fMRI studies usually include several stimuli to detect activation in specific brain areas, while the Rorschach cards are only ten. Thus, the experimental design we adopted in this study may not have been able to detect slight differences in brain activations. Put simply, it is possible that the signal to be measured was only powerful enough for relatively big differences. This would explain why only the differences between brain activations during M responses vs. fixation were significant, while no differences were observed when comparing M vs. Non-M responses. Indeed, the first contrast compared a specific response process on the Rorschach to a clearly diverse psychological process (i.e., the resting condition), while the second contrast compared between two diverse, but similar, psychological processes (i.e., producing M vs. Non-M Rorschach responses). Support for this conjecture comes also from the fact that M responses appeared to be associated with higher activation of MNS related areas both when they were compared to the baseline and when they were compared to the Non-M responses, but only in the first case these results were significant. Accordingly, one might expect future investigations adopting improved experimental designs to be able to also detect significant differences between M and Non-M responses.

A second possible explanation is that not only the production of M responses, but the production of any Rorschach responses is associated, to some extent, with MNS activity. In fact, given that the M

responses were associated with activity in MNS related areas and no significant differences were observed between M and Non-M responses, one should conclude that the production of Non-M responses may also be associated with MNS activity. From a theoretical point of view, this would find some support in the idea that the production of any Rorschach responses relies on an identification/embodied simulation process (see chapter 1). Some empirical data also support these hypotheses. For example, in our first EEG study (Giromini, Porcelli, Viglione, Parolin, & Pineda, 2010), although the attribution of M responses was associated with higher mu suppression as compared to the attribution of Non-M responses, in both the cases some mu suppression might have occurred, in that the mean mu index was negative for both (p. 237). Similarly, in our second EEG study (see chapters 4 and 5), the mean value for the mu index calculated for several response processes ranged from -.15 (for Non-M non human content responses) to -.24 (for M responses). Given that this mu index was calculated as the mean log ratio of power in the mu frequency during the production of Rorschach responses over the power in the baseline condition (i.e., negative values indicate mu suppression), this datum suggests that some mu suppression may have occurred – as compared to the baseline – for all Rorschach responses. Although at first glance this second possible explanation may appear quite suggestive, it should be pointed out that it does not fully account for the different findings obtained by the EEG vs. fMRI studies, such that the influence of technical issues appears more supported, to date.

Other explanations are possible as well. For example, it is possible that participants thought of different responses from what they subsequently reported, and that this has affected the results. Also, it is possible that the activation of the IFG is not strictly related to the MNS

activity but to the fact that thinking of a Rorschach response involves mentally formulating a verbal response. Especially the left IFG, in fact, appears to be extremely important for language production (Dronkers, Plaisant, Iba-Zizen, & Cabanis, 2007). A number of further explanations are possible as well.

Nonetheless, given the fact that two EEG studies (Giromini et al., 2010; Pineda et al., 2011) and part of this fMRI study (i.e., the part relative to the comparison between M responses and fixation) converge in suggesting that there is a link between M responses and MNS activity, to date the first explanation is probably the most realistic one.

## ***Conclusion***

The hypothesis that the M responses on the Rorschach test are associated with embodied simulation and MNS activity is only partially confirmed by this fMRI study. However, as previously discussed, some technical issues may have affected the results in terms of reducing the possibility to detect small differences in brain activations. In addition, some other limitations should be kept in mind while considering these findings. First, the ecological validity of the Rorschach responses is doubtful, due to the fact the participants were observing the Rorschach cards through a small mirror, while immobile in a scanner. Second, the phenomenon of “potential responses”, i.e., representations that the subject sees but that for any reason he or she chooses to not articulate verbally in his or her actual response (Exner, Arbuster, & Mittman, 1978), could not be controlled. Third, the amount of analyzed data was relatively small, in that the functional scanning during the production of

M responses refers to only 40 to 50 seconds, in average. Fourth, the Rorschach responses could not be verbalized immediately after production, and this may have caused an artefact.

Despite all these limitations, this study partially supports the existence of a link between Rorschach M responses and MNS activity, and paves the way for future research on this topic, by providing a relatively unique experimental paradigm and highlighting its limitations.



## References

- Collins, D. L., Neelin, P., Peters, T. M., & Evans, A. C. (1994). Automatic 3D intersubject registration of MR volumetric data in standardized Talairach space. *Journal of Computer Assisted Tomography*, *18*(2), 192–205.
- Dronkers, N. F., Plaisant, O., Iba-Zizen, M. T., & Cabanis, E. A. (2007). Paul Broca's historic cases: High-resolution MR imaging of the brain of Leborgne and Lelong. *Brain*, *130* (5), 1432-1441.
- Exner, J. E., Armbruster, G., & Mittman, B. (1978). The Rorschach response process. *Journal of Personality Assessment*, *42*, 27-38.
- Exner, J. E., Jr (2003). *The Rorschach. A Comprehensive System. Vol. 1. Basic foundations and principles of interpretation (4th edn)*. New York: John Wiley & Sons.
- Friston, K. J., Holmes, A. P., Worsley, K. J., Poline, J. P., Frith, C. D., & Frackowiak, R. S. J. (1995). Statistical parametric maps in functional imaging: a general linear approach. *Human Brain Mapping*, *2*, 189–210.
- Giromini, L., Porcelli, P., Viglione, D., Parolin, L., & Pineda, J. (2010). The feeling of movement: EEG evidence for mirroring activity during the observations of static, ambiguous stimuli in the Rorschach cards. *Biological Psychology*, *85*, 233-241.
- Jellema, T., Baker, C. I., Wicker, B., & Perrett, D. I. (2000). Neural representation for the perception of the intentionality of actions. *Brain and Cognition*, *44*(2), 280–302.
- Molenberghs, P., Brander, C., Mattingley, J.B., & Cunnington, R. (2010). The role of the superior temporal sulcus and the mirror neuron system in imitation. *Human Brain Mapping*, *31*, 1316-1326.

- Perrett, D. I., Harries, M. H., Bevan, R., Thomas, S., Benson P. J., Mistlin, A. J., Chitty, A. J., Hietanen, J. K., & Ortega, J. E. (1989). Frameworks of analysis for the neural representation of animate objects and actions. *Journal of Experimental Biology*, 146, 87–113.
- Perrett, D. I., Mistlin, A. J., Harries, M. H., & Chitty, A. J. (1990). Understanding the visual appearance and consequence of hand actions. In *Vision and Action: The Control of Grasping*, ed. MA Goodale, pp. 163–342. Norwood, NJ: Ablex.
- Pineda, J., Giromini, L., Porcelli, P., Parolin, L., & Viglione, D. (2011). Mu suppression and human movement responses to the Rorschach test. *NeuroReport*, 22 (5), 223-226.
- Rizzolatti, G., & Craighero, L. (2004). The mirror neuron system. *Annual Review of Neuroscience*, 27, 169-192.

## CHAPTER 7

### Summary, Discussion, and Final Considerations

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As reviewed in chapter 1, the rationale for the traditional interpretation of the human movement (M) response on the Rorschach test as an index of empathy and mentalization relies on the fact that this response, according to several Rorschach theorists, is based on the mechanism of identification: individuals identify themselves with the other human figure seen in the blot, while ‘simulating’ the feeling of movement within themselves, as if they move themselves (see, for example, Malmgren, 2000; Piotrowski, 1977; Rorschach, 1921). Such a psychological process closely resembles that of embodied simulation, a functional mechanism through which the actions, emotions, or sensations we see activate our own internal representations of body states that are associated with these social stimuli, as if we were engaged in a similar action or experiencing a similar emotion or sensation (Freedberg & Gallese, 2007). According to a growing body of evidence, such a mechanism – i.e., the embodied simulation – finds a neurobiological substrate in the neural matching mechanism constituted of a specific set of cells named mirror neurons (Gallese, 2001, 2003).

Given the conceptual overlapping between the identification process behind the production of M responses and the mechanism of embodied simulation, we hypothesized that the production of Rorschach M responses would be associated with mirror neurons activity as well. Noteworthy, both M responses and mirror neurons

activity are believed to be related to social cognition and social competence.

A series of studies investigated this hypothesis.

A first, pilot, study (see chapter 2) exploited a phenomenon known as 'neurological priming' (see, for example, Gillmeister, Catmur, Brass & Heyes, 2008; Leng & Shaw, 1991; Raushcer, Shaw, & Ky, 1993; Vogt, Taylor & Hopkins, 2003), according to which preactivating specific cerebral regions might 'prime' functions and behaviors related to such regions. A small sample of students were administered some Rorschach cards immediately after having showed them some short videos expected to activate the mirror neuron system (MNS) at different levels. It was hypothesized that if M responses to the Rorschach were associated to MNS activity, then the participants would produce more M responses when exposed to the videos that activate more intensely the MNS. Results did not strongly support this hypothesis, however a linear trend (albeit nonsignificant) in the expected direction was observed. This encouraged us to continue working on the main idea of the research.

Accordingly, a second experiment was undertaken. In this second study (see chapter 3), we aimed to investigate more directly the brain activity during exposure to different Rorschach stimuli. A few selected Rorschach cards were administered, along with some drawings, to a small sample of students, while recording their EEG data. Since previous studies (Cochin et al., 1998; Oberman et al., 2005, 2007a,b; Pineda, Allison & Vankov, 2000) linked activity in the human MNS with suppression in the EEG mu frequency band (i.e., 8-13 Hz over sensorimotor cortex), we expected mu suppression to occur during exposure to some stimuli that elicit feeling of movement (i.e., Rorschach cards with high M response frequency in the normative database) as compared to some other stimuli that do not elicit feeling

of movement (i.e., Rorschach cards with low M frequency in the normative database). Results confirmed our hypothesis and suggested – for the first time – that the self-initiated “feeling of movement” internally perceived and cognitively processed by the subjects exposed to the Rorschach cards is a powerful stimulus for modulating the MNS activity.

To overcome some technical limitations of said EEG study, a third study (see chapter 4) was undertaken. Again, the EEG methodology was utilized and the mu suppression phenomenon was used as criterion. In this study, the entire set of Rorschach stimuli was administered to a larger sample of students, and the association between MNS activity and several Rorschach responses was further investigated. Results, again, confirmed that mu suppression was higher during M responses as compared to other than M (Non-M) responses. Of note, with better controls, the effect size was almost three times ( $\eta^2 = 0.17$ ) that of the previous study ( $\eta^2 = 0.06$ ), falling in the large range of suggested benchmarks (small = 0.01; medium = 0.06; large = 0.14) (Kittler, Menard & Phillips, 2007).

To further investigate the link between M responses, social cognition, and mu suppression, a fourth study (see chapter 5) was carried on. In this study, the data set of study 3 (i.e., our second EEG study, see chapter 4) was re-analyzed, but this time a greater number of Rorschach responses were coded and two additional hypotheses were investigated. First, we hypothesized that mu suppression would not occur for non-human movements (i.e., FM or m), non-moving human contents (i.e., H, (H), Hd, or (Hd) in the absence of M), and other Rorschach responses such as shading or pure form, in that – differently from M responses – such responses are not interpreted as indices of social cognition and social competence. Second, we hypothesized that M responses expected to be more strictly related to

social cognition and social competence (e.g., adequately perceived human beings in movement) would be more strongly associated to mu suppression than M responses more related to poor social skills (e.g., distorted perceptions of human beings in movement). Results confirmed these hypotheses only partially. From the one hand, none of the several Rorschach responses taken into account was as strongly associated with mu suppression as was the M response. However, from the other hand, the association between the quality of M responses and the degree of mu suppression was not clear and some controversial results were observed.

Finally, a fifth study (see chapter 6) using functional magnetic resonance imaging (fMRI) was conducted. The main goal of this study was to investigate the link between M responses and MNS activity with a higher spatial resolution technique, and explore, in case, to what extent the premotor MNS and other regions that are part of a larger action observation/execution network are involved. For this purpose, the entire set of Rorschach cards was administered, two times, to a sample of 23 volunteer participants during fMRI. While in the scanner, the participants were asked to think of what each card might be, and after that, in a separate room, they were inquired about their responses. Because the human MNS is mainly constituted by the rostral part of the inferior parietal lobe (IPL), the lower part of the precentral gyrus (ventral premotor cortex; vPMC), the posterior part of the inferior frontal gyrus (IFG; for a review, see Rizzolatti & Craighero, 2004), and possibly the superior temporal sulcus (STS; Jellema et al., 2000; Molenberghs, Brander, Mattingley, & Cunnington, 2010; Perrett et al. 1989, 1990), we expected these areas to be involved during the production of M responses. Results partially confirmed our hypotheses. As compared to the baseline, the production of M responses was significantly associated with activations both in regions associated with

visual processing and in regions related to the MNS – primarily the IFG, but also the vPMC and the IPL. Nonetheless, when compared to the production of Non-M responses, the production of M responses did not show any statistically significant differences in terms of brain activity.

Taken together, these five studies suggest that the production of M responses on the Rorschach test is associated with MNS activity. In fact, despite some controversial issues, the convergence of a number of different sources of information highly supports said association. Accordingly, the hypothesis that the production of M responses is based on the mechanism of embodied simulation (or identification, as suggested by several Rorschach theorists) finds a neurophysiological foundation in this work, with important implications for the clinical interpretation.

As noted in chapter 1, the rationale for interpreting M responses as indices of empathy and mentalization relies on two main theoretical considerations – which both postulate that M responses rely on the identification mechanism. First, when the subject reproduces within himself the feeling of movement seen in the blot, to some extent he or she also identifies with the moving human figure seen in the blot. Therefore, M responses are thought to reveal information about the respondent's ability to identify with other human beings. Second, to be able to match internally generated representations of human movements with externally existent ambiguous stimuli, it is necessary that the representation of such human movements is present and available in the mind of the subject. Thus, to be able to produce M responses, the subject has to be able to think about human beings and human movements.

By supporting the assumption that an identification/embodied simulation mechanism lies beneath the M response, our findings

provide a neurophysiological foundation for the concept these theoretical considerations are built upon. Consequently they provide some indirect support for the traditional interpretation of M responses. In addition, because the human MNS is thought to provide the neural basis for unique human social skills such as empathy, theory of mind, mentalization, and facial emotion processing (Gallese, 2001; Gallese, 2006; Gallese & Goldman, 1998; Pelphrey & Morris, 2006; Uddin, Iacoboni, Lange, & Keenan, 2007), more direct proof is also provided. The brain activity underlying the response process behind the production of M responses, indeed, is directly related to the abilities the M response is supposed to measure.

To say it in other words, the observed association between M responses and MNS activity supports the traditional interpretation of M responses, not only indirectly, by supporting its basic assumption (i.e., that M responses rely on an identification mechanism), but also more directly, by linking its response process to a neurological system associated with the constructs that the M responses are supposed to measure (i.e., mentalization and empathy).

Of interest, some early Rorschach theorists predicted similar findings many years ago. Zygmunt Piotrowski, in particular, back in 1960 referred to M responses by saying: "These responses are potential, not actual, actions. One might say they are initial stages of actions at a very low level of intensity. Carefully controlled and precise electromyographic investigations probably would demonstrate a parallelism between the patterns of electric currents during the spontaneous production of various types of M and during overt manifestations of actions indicated by the same M" (Piotrowski, 1960). Clearly, although we focused on the brain's activity instead of muscles', this hypothesis finds a sort of confirmation in our findings. As reviewed in chapter 1, indeed, mirror neurons discharge not only during action



execution but also during action observation, and the MNS is often considered as an observation/execution matching system (Oberman, Pineda, & Ramachandran, 2007; Pineda, 2005). Therefore, the involvement of the MNS supports Piotrowski's hypothesis about the existence of a parallelism between spontaneous production of Ms and overt manifestations of actions indicated by the same M.

The extent to which our findings validate the traditional interpretation of M responses, however, is somewhat singular. Traditionally, indeed, the construct validity of a test – roughly said, the extent to which the test measures the theorized constructs it is claimed to measure – is investigated by using several instruments within the same method family. For example, a self-report is often tested by correlating its total scores with those of other self-reports measuring similar constructs. This is not the case, in our study. Our goal was to refine the understanding of what M (and M related) responses mean, and in the attempt to reach this goal we employed heteromethod (or interdisciplinary) procedures (i.e., we exploited the phenomenon of the neurological priming and utilized EEG and fMRI techniques) and focused exclusively on the response process – and not on total scores.

As stated by Meyer, Viglione, Mihura, Erard, & Erberg (2011), the “Rorschach is a behavioral task that provides wide latitude for idiographically unique responses, in which the enacted behaviors are an expression of one's underlying psychological habits, personality features, and processing style. As a behavioral task, the best or most valid interpretations derived from the task are those that link to mental, verbal, and perceptual behaviors in the external environment that parallel those observed in the microcosm of the task” (p. 317). In our study we examined the validity of M (and M related) responses by focusing directly on the response process, and studying the behavior of respondents ‘in the microcosm of the task’. After reviewing many

theories regarding the M response, we found that most of them share the idea that the response process underlying the production of M responses is characterized by an identification mechanism. Thus we challenged this specific feature by hypothesizing that if such an identification mechanism occurred during the production of M responses then the MNS would be involved as well. The results confirmed our hypothesis and hence suggested that what many theorists believed to happen ‘in the microcosm of the task’ – i.e., that an identification mechanism lies beneath the production of M responses – is likely to happen for real.

Nonetheless, we did not investigate whether a parallelism also exists between the behaviors observed ‘in the microcosm of the task’ and those ‘in the external environment’. Said differently, this research suggests that ‘in the microcosm of the task’, the production of M responses is likely to reflect the ability to identify with other human beings and think about people. However, the way and the extent to which these responses are also associated with MNS functioning and actual behaviors ‘in the external environment’ remains an empirical question.

Future studies, accordingly, should focus on individual differences and observed behaviors, and test whether the association between M responses and MNS activity ‘within’ the test extends also ‘outside’ it. For example, a research question can be raised on whether the functional connectivity of the MNS ‘in the external environment’ is associated with the production of M responses ‘in the microcosm of the task’. Another interesting question would be to test whether the number and quality of M responses in the Rorschach are associated to MNS activity during empathy tasks, or theory of mind tasks. Also, it would be important to test whether the degree of involvement of the MNS during the Rorschach test is linked to the extent to which a person shows

empathy or mentalization abilities in the real world. Many other open questions remain to be answered. By showing, for the first time, that the production of M responses on the Rorschach test is linked to the activity of the MNS, however, the results of these five studies provide new important support to the traditional interpretation of M responses as indices of imagination, empathy, and mentalization of one's own and other's experiences and actions.

## References

- Cochin, S., Barthelemy, B., Lejeune, S., Roux, J., & Martineau, J. (1998). Perception of motion and qEEG activity in human adults. *Electroencephalography and Clinical Neurophysiology*, *108*, 287-295.
- Freeberg, D., & Gallese, V. (2007). Motion, emotion and empathy in esthetic experience. *Trends in Cognitive Science*, *11*, 197-203.
- Gallese, V. (2001). The 'shared manifold hypothesis': From mirror neurons to empathy. *Journal of Consciousness Studies*, *8*, 33-50.
- Gallese, V. (2003). The roots of empathy: the shared manifold hypothesis and the neural basis of intersubjectivity. *Psychopathology*, *36*, 171-180.
- Gallese, V. (2006). Intentional attunement: A neurophysiological perspective on social cognition and its disruption in autism. *Brain Research*, *1079*, 15-24.
- Gallese, V., & Goldman, A. (1998). Mirror neurons and the simulation theory of mind-reading. *Trends in Cognitive Science*, *2*, 493-501.
- Gillmeister, H., Catmur, C., Brass, M., & Heyes, C. (2008). Experience-based priming of body parts: a study of action imitation. *Brain Research*, *1217*, 157-170.
- Jellema, T., Baker, C. I., Wicker, B., & Perrett, D. I. (2000). Neural representation for the perception of the intentionality of actions. *Brain and Cognition*, *442*, 280–302.
- Kittler, P., & Turkewitz, G. (1999). The talking face: Effects of concurrent speech on hemispheric lateralization of face recognition. *Developmental Neuropsychology*, *16*, 253–271.

- Leng, X., & Shaw, G. L. (1991). Towards a neural theory of higher brain function using music as a window. *Concepts in Neuroscience, 2*, 220–258.
- Malmgren, H. (2000). Rorschach's Idea of a Movement Response in the Light of Recent Philosophy and Psychology of Perception. *Rorschachiana, 24(1)*, 1-27.
- Meyer, G. J., Viglione, D. J., Mihura, J., Erard, R. E., & Erdberg, P. (2011). *Rorschach Performance Assessment System: Administration, coding, interpretation, and technical manual*. Toledo, OH: Rorschach Performance Assessment System.
- Molenberghs, P., Brander, C., Mattingley, J.B., & Cunnington, R. (2010). The role of the superior temporal sulcus and the mirror neuron system in imitation. *Human Brain Mapping, 31*, 1316-1326.
- Oberman, L. M., Hubbard, E. M., McCleery, J. P., Altschuler, E. L., Ramachandran, V. S., & Pineda, J. A. (2005). EEG evidence for mirror neuron dysfunction in autism spectrum disorders. *Cognitive Brain Research, 24*, 190-198.
- Oberman, L. M., McCleery, J. P., Ramachandran, V. S., & Pineda, J. A. (2007a). EEG evidence for mirror neuron activity during the observation of human and robot actions: Toward an analysis of the human qualities of interactive robots. *Neurocomputing, 70*, 2194-2203.
- Oberman, L. M., Pineda, J. A., & Ramachandran, V. S. (2007b). The human mirror neuron system: A link between action observation and social skills. *Social Cognitive and Affective Neuroscience, 2*, 62-66.
- Pelphrey, K. A., & Morris, J. P. (2006). Brain mechanisms for interpreting the actions of others from biological motion cues. *Current Directions in Psychological Science, 15*, 136-140.

- Perrett, D. I., Harries, M. H., Bevan, R., Thomas, S., Benson P. J., Mistlin, A. J., Chitty, A. J., Hietanen, J. K., & Ortega, J. E. (1989). Frameworks of analysis for the neural representation of animate objects and actions. *Journal of Experimental Biology*, *146*, 87–113.
- Perrett, D. I., Mistlin, A. J., Harries, M. H., & Chitty, A. J. (1990). Understanding the visual appearance and consequence of hand actions. In *Vision and Action: The Control of Grasping*, ed. MA Goodale, pp. 163–342. Norwood, NJ: Ablex.
- Pineda, J. A. (2005). The functional significance of mu rhythms: Translating “seeing” and “hearing” into “doing”. *Brain Research Reviews*, *50*, 57-68.
- Pineda, J. A., Allison, B. Z., & Vankov, A. (2000). The effects of self-movement, observation and imagination on mu rhythms and readiness potentials (RP's): Toward a brain-computer interface (BCI). *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, *8*, 219-222.
- Piotrowski, Z. A. (1960). The movement score. In M. Rickers-Ovsiankina (Ed.), *Rorschach psychology* (pp. 49–58). New York: John Wiley.
- Piotrowski, Z. A. (1977). The movement responses. In M. A. Rickers-Ovsiankina (Ed.), *Rorschach psychology*. Huntington, NY: Krieger. Pp. 189-227.
- Rauscher, F. H., Shaw, G. L., & Ky, K. N. (1993). Music and spatial task performance. *Nature*, *365*, 611.
- Rizzolatti, G., & Craighero, L. (2004). The mirror neuron system. *Annual Review of Neuroscience*, *27*, 169-192.
- Rorschach, H. (1921). *Psychodiagnostik*. Bern: Bircher.
- Uddin, L. Q., Iacoboni, M., Lange, C., & Keenan, J. P. (2007). The self and social cognition: The role of cortical midline structures and mirror neurons. *Trends in Cognitive Sciences*, *11*, 153-157.

Vogt, S., Taylor, P., & Hopkins, B. (2003). Visuomotor priming by pictures of hands: perspective matters. *Neuropsychologia*, 41, 941-951.